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THE DIAGNOSTIC VALUE AND INTERPRETATION OF CEREBRO-SPINAL DETERMINATIONS*

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I. SPINAL PUNCTURE

THE procedure of lumbar, or spinal, puncture has become almost a constant necessity for correctly determining diagnosis and in the treatment of certain diseases. It is, however, not without danger and three of the foremost causes for many of the fatalities reported are:

1. *Meningitis,* due to the introduction of some pyogenic organism at the time of puncture.

Such a case has recently been treated on the medical service of the University Hospital. The patient (A. B.) had been punctured elsewhere 14 days previously. Soon after, he developed typical signs of a purulent meningitis, and was admitted to this hospital in a stuporous condition with a positive Kernig's sign, leucocytosis, fever, marked rigidity of the neck and a history of previous spinal puncture. Lumbar puncture showed purulent fluid; cisternal puncture also showed a cloudy fluid. Following a lavage with normal saline solution of the basal cistern and washing out of the spinal column, the patient regained consciousness within a few hours and appeared to be brighter. Doctor Piper's method of intravenous mercurochrome administration was resorted to, with the result that after three injections, the temperature returned to normal and the man's life was spared. He is now becoming ambulatory and will soon be discharged from the service.

Cultures from the lumbar and cisternal regions constantly showed staphylococcus aurius to be present.

Therefore careful preparation of the skin should be undertaken. Alcohol in itself is not sufficient and gloves should be worn to prevent possible contamination. Some solution, such as iodine or picric acid, should also be employed to obviate this danger.

2. The second source of danger lies in the variable pressure factors which may be present. A point which cannot be too strongly emphasized is the determination of pressure in every instance. If the case warrants spinal puncture, pressure values are always important. This should be done with an approved type of manometer. In cases where the pressure is above 18 mm. of Hg., when the patient is recumbent, no fluid should be withdrawn until the pressure can be further reduced by other means (dehydration). The many cases of sudden death reported following lumbar puncture (and just as

* Read before the Philadelphia Academy of Surgery, April 7, 1924.

many, if not more, that are never reported) are usually due to increased intracranial pressure too often unrecognized; and to the withdrawal of large amounts of fluid in these cases. With the escape of fluid from the spinal needle, the ventricular pressure within the brain above forces down the structures at the base so that the cerebellum may be jammed into the foramen magnum causing a " foraminal cone " or hernia. Depression of the respiratory and cardiac functions ensue and sudden death may occur. One cannot safely make a study of cerebrospinal fluid without a manometer any more than one can intelligently treat a case of fever without a thermometer.

3. The third source of danger is, although rare, indeed a real one and perhaps is the cause of more delayed, undetermined deaths than any other. This is due to thecal tears by the use of large needles which leave rents in the dura after their withdrawal. It is obvious that when cerebrospinal pressure is increased, a tear in the dura allows the fluid to escape unbeknown to the physician or patient. This fluid finds its way into the sacral area which is capable of holding 40 to 60 c.c., hence foraminal hernia may develop a few hours after lumbar puncture, where pressure is increased, even though no fluid has been removed at the time of puncture. Therefore, it is wise to use fine needles so constructed that the danger of breaking off is negligible. We have in the Labat spinal needle a French nickeloid steel, an ideal instrument for spinal puncture. The Lewisohn needle has many advantages in that it is attachable to a manometer and has a tap cock which allows no escape of fluid but immediate pressure readings. It is further constructed so as to give a glass barrel to a portion of the needle which allows the operator to see the presence of fluid as soon as the puncture has been successfully completed.

FIG. 1.—Posterior aspect of the skull. 1. Occipital protuberance. 2. Distance from the midline (marked with an X) for trephine opening.

Ayer, who uses a spinal fluid manometer consisting of a glass tube connected at right angles to the needles, reads his pressure by the rise of fluid in the glass tubing (mm. of hydrostatic pressure). He has even gone so far as to inject a small amount of horse serum following lumbar puncture, in order to facilitate coagulation around the thecal tear made by introducing the needle through the dura. This refinement in technic is not always necessary, but shows to what extent Doctor Ayer regards the gravity of thecal tears in the presence of increased intracranial pressure.

Pathologic Fluids Obtained.—A brief summary of the types of fluids seen under various conditions consists of:

1. *Cloudy.*—(Opalescent to purulent) found in meningitis and irritative conditions of the cord and meninges.

2. *Hemorrhagic.*—(a) This may be of local origin and due to puncture of a small dural or arachnoid vessel. Usually the fluid becomes clear and, if the first few drops are compared with the next few, a difference in color will establish this fact.

(b) Remote hemorrhages usually show uniformly bloody spinal fluid which upon centrifuging leaves a yellowish supernatant fluid. The condition is found in cortical injuries due to contusion or laceration, and in fracture of the skull, injury to the cord, spontaneous hemorrhage, etc. Hemorrhages in the cortex and into the ventricles may also show blood in the spinal fluid following certain types of hæmoplegia. It is, therefore, often a useful diagnostic test for differentiating thromboses from hemorrhage.

FIG. 2.—Posterior aspect of the skull showing measurements. 1. Six cm. from the occipital protuberance toward the vertex. 2. A distance of 3 cm. from the midline to the right or left depending upon the ventricle to be entered.

In a recent paper, by Sharpe,† 6 per cent. of apparently normal deliveries, spinal fluid taken from the infant a few hours later showed blood due to some cranial injury. Repeated punctures should be made in these cases and fluid withdrawn each day until it becomes clear.

3. *Xanthrochromia.*—(a) In old hemorrhages, the fluid will be found clear and, upon standing, does not coagulate.

(b) Rapid coagulation and a yellowish fluid are known as *Froin's syndrome,* and indicates a tumor of the cord or meninges, or a complete block in the spinal canal.

(c) Jaundice may cause a yellowish fluid which has no significance in the presence of either clinical signs or other hepatic disturbances.

Tests and Their Practical Values.—A brief summary of only the practical test for differential diagnosis is here given. (Many established and complicated determinations may be made, but these are only possible in conjunction with a well-equipped laboratory and hence are not easily available to the surgeon or general practitioner.)

1. The valued Wassermann reaction need not be discussed.

2. The colloidal gold determination is of great importance and curves obtained from this reaction may be of great value in assisting to definitely diagnose certain conditions. The colloidal gold reaction should *not* be considered as purely a test for syphilis, for many conditions give characteristic curves which are quite different from those found in tabes, or paresis. One should emphasize to the laboratory technician that a report of whatever

† Sharpe and Maclaire: Surg. Gyn. and Obst., vol. xxxviii, p. 200, Feb., 1924.

TABLE I.

*Cytological and Chemical Findings.**

Disease	Sugar			Albumin			Cells			
	Absent	Normal	Increased	Absent	Normal	Increased	Lymhos.	Polys.	Both	Spec.
Meningomyelitis:										
Tuberculous	—					++++	+++	+		
Syphilitic	Reduced					++++	+++			
Meningitis:										
Acute	Absent					++++		++++		
Chronic	Reduced						+			
Tuberculosis:										
Acute	Reduced					++++	+	++	Yes	
Chronic	—					++++	++++			
Poliomyelitis							+++	+	Yes	
Progressive poliomyelitis		√				Trace to ++	++	+	Yes	
Tabes	Reduced					++	++			
Paresis	Reduced					++++	+++			
Chorea		√			√		+	+		

Herpes		√			√		+			
Mumps		√			√		+			
Leukemia							+			
Tumor of the cord		Usually √				+++++ Clots	+	Few		Tumor cells.
Tumor of the Brain Glioma		Usually √				Usually increased	++			Tumor cells.
Yeast										Yeast cells.
Cysticercus infection							+			Eosin-ophils.
In general: Acute infections Chronic infections	Absent Reduced					++++ + to ++++	++++	++++		
Encephalitis			++		√ or a trace		+			
Diabetes			++							

* This table revised and corrected by the kind assistance of Dr. John A. Kolmer.

curve found should be returned and not simply the statement that it is luetic or non-luetic, as is so frequently the case. The following groups, as they occur in the chart for colloidal gold reduction, reading from left to right (that is, in the lower dilutions and intense color of red toward the higher dilutions and the range of color to white), we find:

(a) General paralysis of the insane (paresis).
(b) Cerebrospinal syphilis, or tabes.
(c) Anterior poliomyelitis.
(d) Tuberculous meningitis.
(e) Purulent meningitis, including brain abscesses.

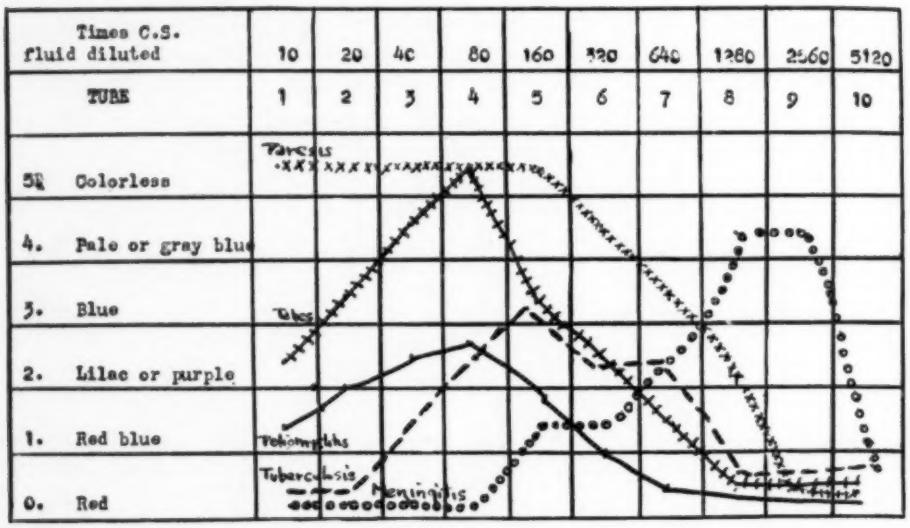

FIG. 3.—Colloidal gold curves. (After Regan and Cheney.)

So often blood-stained spinal fluid is said to vitiate colloidal gold readings, but it should be borne in mind that the presence of blood plasma in the spinal fluid will give a curve similar to that found in tuberculous meningitis and should not greatly interfere with the reading for paresis and tabes. It is evident that curves for the other conditions, when substantiated by clinical manifestations, are of great importance in determining the injury or disease of the brain and spinal cord.

Chemical and Cytological Findings.—The table on pages 644 and 645 has been constructed for easy reference and in general holds good in the following diseases.

Bacteriological Findings.—The following organisms may appear in the spinal fluid and should be looked for in cases where indicated. 1. Tubercle bacillus. 2. Typhoid bacillus. 3. Pneumococcus. 4. Diplococcus, intracellularis. 5. Anthrax bacillus. 6. Streptococcus. 7. Staphylococcus. 8. Yeast cells. 9. Tumor cells. 10. Trypanosomes.

II. SPINAL DRAINAGE

This procedure has been advocated in cases of intracranial injuries following childbirth where bloody cerebrospinal fluid is obtained.‡ Repeated drainage should be maintained until the fluid becomes clear. Cases in which hemorrhagic fluids are obtained following intracranial injuries or fracture of the skull after infancy usually do best when drainage is not instituted. Spinal drainage has been found of value in sunstroke, migraine, uræmic coma, puerperal eclampsia and purulent meningitis. In some cases of increase in intracranial tension, due to meningitis about the base of the brain, or brain tumor, it must be borne in mind that there is great danger in producing foraminal hernia and sudden death if much fluid is removed. The safer procedure would be ventricular puncture but, if this is not feasible, then fluid may be withdrawn from the lumbar needle after careful determinations of the initial pressure, and never allowing pressure to fall more than 5 or 10 mm. of Hg. at one time. Small amounts of fluid may be repeatedly withdrawn but always there is the source of danger above mentioned. Spinal drainage may be resorted to in cases where antiluetic treatment has been administered. (Swift-Ellis treatment.)

FIG. 4.—Point of entry into the brain showing the needle in place.

The patient should be placed on the face, with the feet elevated to avoid danger of cerebellar foraminal hernia. Serums and medications which are desired may be administered after the canal has been drained. These will be discussed under cisternal puncture.

III. THE QUECKENSTEDT TEST

This test is of value in determining spinal block and has been emphasized by Ayer, Cushing, and Mixter. It consists in compression of the jugular veins of the neck in such a way as to obstruct the outflow from the cranial cavity aud thus increase congestion of the brain, causing a rapid transitory rise in pressure which is manifested not only by cyanosis of the face, but a subjective feeling of fullness in the head and, of course by spinal manometer where no obstruction between the ventricles and the base of the cord exist. Two other advantages arise from this test; namely a true determination of pressure showing the manometer to be accurate regarding the initial rise. A return to the former reading by the manometer usually occurs within a few moments. The column of mercury rapidly receding to its former level. Second, fluid may be obtained in cases where "a dry tap" sometime has failed to yield fluid. If the needle be properly in

‡ Sharpe, etc., *Loc. Cit.*

place, jugular pressure will force fluid from it, and this has occurred in several instances where "a dry tap" was thought to have been present.

If obstruction occurs between the fourth ventricle and the base of the cord, due to tumor, fracture, dislocation, caries, exudate or pachymeningitis, it will be found usually that the initial reading is low (4-6 mm. Hg.). When the Queckenstedt test is applied, the rise of pressure, as recorded by the spinal manometer, is gradual and slow and never prompt. It is difficult to get readings as high as 20 mm. Hg. if the initial reading was subnormal (below 8 mm. Hg.).

After jugular constriction has been relieved, the fall to normal is very slow and a mean point may be reached where no further fall occurs. It is, therefore, of value in determining spinal block, but does not, of course, indicate the level of the lesion—other examinations must reveal this.

IV. LIPOIDAL INJECTION

The use of an opaque substance, such as lipoidal, in the spinal canal has been advocated by Sincard,§ using an emulsion of iodine and potassium iodide in a heavy oil. He found this substance when introduced into the spinal canal, could be easily moved about by change in posture and in cases of tumor, or obstruction of the canal, the substance came to rest at a definite point which would then be determined by X-ray studies as the substance throws a heavy shadow distinct from any normal X-ray shadow of the vertebræ. This method was tried for the first time in this clinic last October. In one case, an old fracture-dislocation of the spine, there developed such intense signs of root irritation following injection that the procedure has been regarded as very limited in its application.

V. SPINAL ANÆSTHESIA

This subject is so diverse and specialized in its application that no attempt will be made to outline the procedure.

VI. CISTERNAL PUNCTURE

This operation of introducing a needle into the basal cistern has a limited application but, when indicated, is one of our most dependable means of obtaining certain information and results. It should be borne in mind that cisternal puncture, although less difficult than lumbar puncture, is not without added dangers due to the proximity of the medulla and the vital centres. It

§ Sicard's method was to place the patient in the sitting posture and make the injection of the opaque substance into the Cisterna Magna—after injection, the patient was generously thumped on the back and X-rays taken in the sitting posture showed the arrest of the substance above the point of obstruction.

The possibilities of its use suggest themselves as a means of differential diagnosis but one must bear in mind the possible irritative effects, the fact that the substance behaves much like quicksilver and cannot be recovered again and also its slow absorption characteristics are to be seriously considered.

Since the case above mentioned, several other observations have been entirely satisfactory.

should never be attempted in cases where increase in intracranial pressure is found or suspected, because intense pressure from above, due to ventricular obstruction, may force the cerebellar hemispheres into the foramen magnum and the entering needle produce a cortical laceration with hemorrhage and possible disaster in the outcome of the case. There should be a "stop" or check on the needle so that it is not allowed to slip beyond the point of dural penetration, else the vital structures of the cord may suffer. Its indications, however, are quite clear cut in determining spinal block and in certain types of medication. Where cord tumor, spinal caries, subluxation due to trauma with pressure on the cord is suspected and a consequent "spinal block," a needle is first introduced into the lumbar region and pressure readings obtained by manometer. Another needle, with a separate manometer attached, is then introduced into the basal cistern. The Queckenstedt test, as above described, will determine the presence or absence of a spinal block by observing the response in the spinal needle, comparing its variation with that of the cistern—they should be alike in normal subjects. The presence of a block is manifested by a rapid rise in the cisternal needle, the pressure reaching 20 to 30 mm. of Hg. upon jugular compression. If the spinal block be present, however, the lumbar needle may not register any increase of pressure or perhaps only a gradual rise which always lags behind that seen in the cisternal manometer and when jugular compression has been released, that rapid fall in the cisternal manometer precedes any change recorded from below by the registering pressure in the lumbar region. In case of block, this is quite marked and unmistakable in its significance. By using the height of spinal fluid pressure itself, as advocated by Ayer, where a glass tube is connected at right angles to the needle, respiratory fluctuations may be noted in one or both areas and even the pulse wave may be transmitted. Such delicate manifestations are at once obliterated in the lumbar manometer when some obstruction of the canal occurs between the base of the brain and the lumbar region. This test, of course, does not indicate the level of the lesions. A similar combination of ventricular puncture with a needle placed in one or both ventricles and a cisternal needle registering pressure may help to determine the presence of ventricular block. Phenolphthalein or indigo carmine injected into the ventricular needle may be obtained from the cisternal needle within a few moments if no obstruction exists.

FIG. 5.—Cisternal puncture, showing the direction of the needle and its relation to the occipital protuberance and the foramen magnum.

The use of the cisternal puncture for therapeutic means has a definite

value. Lavage of the cistern and the spinal cord may be obtained in cases of meningitis. Washing through the entire length of the cord by normal saline solution is especially effective in purulent meningitis. Medication may be introduced for lues (blood plasma following intravenous injection and centrifuging may be reinjected through the cisternal needle); specific serums may be introduced for epidemic cerebrospinal meningitis, tetanus, pneumococcus, staphylococcis, etc. Antiseptics, such as mercurochrome 1 per cent., is sometimes used in cases of tetanus and seditives such as bromides in delirium tremens with beneficial results.¶

FIG. 6.—Anterior aspect of the skull. Needle in place for cisternal puncture. Note the "stop" on the shaft of the needle, consisting of a safety tie pin clasp to prevent its introduction beyond the dura after its insertion. The point of the needle will be seen just entering the foramen magnum.

VII. VENTRICULAR PUNCTURE

This procedure has been much discussed by Dandy, Grant and others, and consists in introducing a Cotton cannula into the posterior horn of the lateral ventricle. Intracranial pressure may be determined: the size and shape of the ventricles may be shown by X-ray studies after the introduction of air to replace the fluid withdrawn. Ventricular estimation to determine the size of the ventricle by the amount of fluid obtained and in order to test for a block between the lateral ventricle and the opening of the aqueduct of Sylvius at the base, as described above by means of certain dyes, recoverable in the lumbar or cisternal fluids, and noting the time required for appearance of the colored liquid from the cisternal or lumbar needles. Perhaps one of its most valuable indications is the rapid means for relief of intracranial tension. Cases following acute injuries to the brain with the temporary increase in pressure, where the shocked condition of the patient prohibits dehydration, may be carried over this initial period of transitory pressure increase by ventricular puncture which is far easier to accomplish and less shocking to the patient than suptemporal decompression, and in skilled hands almost without danger. Several instances have arisen on the neuro-surgical service in which sudden respiratory failure occurred due to intense increase in intracranial pressure. The heart maintained its activity over a period of several minutes, ventricular tap relieved the pressure so that respiratory function was again established.

The subject of ventriculography has only special application and significance as an aid in the localization of brain tumors, and has been highly developed in the hands of Doctor Grant here in Philadelphia. X-ray pictures of the ventricles, filled with air, are of great assistance in determining the

¶ Purvis, Stewart: The Diagnosis of Nervous Diseases; Edward Arnold, London.

size and location of certain types of brain tumors. Ventriculoscopy has been attempted and photographs obtained of ventricles of the brain in a hydrocephalic child by means of a photographic cystoscope. It is possible, in the presence of enlarged ventricles, such as those seen in hydrocephalus and in tumors which obstruct the ventricular system causing intracranial pressure, to view the inside of the ventricle by means of a No. 10 cystoscope introduced in the same way as the Cotton cannula for ventricular puncture.

SUMMARY

We may, therefore, say that much of practical value may be obtained by spinal, cisternal and ventricular punctures; always undertaking these operations with the aid of a manometer, carefully noting pressure conditions as they exist and studying the fluid conditions for its various pathological conditions.

It affords a direct means of medication to the spinal canal where indicated.

THE MECHANISM OF POST-OPERATIVE HEMORRHAGE

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In the present state of our knowledge, drainage by one means or another —rubber and glass tubes, rubber dam, gauze, etc.—is a necessary and important factor in practical surgery. The chief danger of drainage, especially when tubes are employed, is hemorrhage and discussion about the various ways of accomplishing drainage rests chiefly on, and centres about a method which is least likely to be followed by secondary hemorrhage. Secondary hemorrhage is especially important in abdominal surgery for the reason that opportunity for the bleeding to remain hidden is frequently present and the condition of the patient may reach a very precarious state before measures can be instituted for the ligature of the bleeding vessel. Indeed, if one considers the large number of cases of intra-abdominal disease which, after laparotomy, must necessarily be drained and in whom the drainage apparatus must of necessity lie in close proximity to a large artery or vein, it seems surprising that so few cases of secondary hemorrhage are encountered.

It is quite probable that the number of such cases of secondary hemorrhage is fairly numerous. However, the literature contains comparatively few recorded instances. Such accidents are reported by Torrance, White, Skerington, Corber, and Ward. Beyond the mere mention of the fact of secondary hemorrhage no one of these reports contains any information which would point out the reasons for the post-operative bleeding. Karpeles in reporting such a case says that: "Secondary hemorrhage is caused by a purulent periarteritis, arterionecrosis taking place. The drainage media, the pus, and the sutures are important factors."

Phifer's report contains the above-mentioned cases. Phifer includes these among other cases in which the secondary bleeding was due to other causes and occurred in the stomach, duodenum, etc.

In Moschcowitz's (1908) case the secondary hemorrhage had followed the withdrawal of rubber drainage tubes inserted at the close of an extraperitoneal operation for the removal of bilateral ureteral calculi; the wounds are described as having "healed by primary union." The importance of this case lies in the fact that owing to the nature of the operation no peritoneum intervened between the drainage tube and the external iliac arteries from which the bleeding occurred. Because of this fact Moschcowitz was led to believe at that time that hemorrhage could not ever occur if the blood-vessel was protected by an intact covering of healthy peritoneum.

We give herewith the notes of several cases in which this accident occurred:

CASE I.—Hospital No. 227512. The patient, a boy of sixteen years, was admitted to the hospital on February 18, 1923 as an ordinary case of acute appendicitis with spreading peritonitis. For six days prior to admission the patient had had a sore throat and had complained of headache, anorexia, lassitude, fever and chilly sensations. Three days before admission to the hospital he was seized with severe pain in the left upper quadrant of the abdomen, accompanied by fever and vomiting. The next day the pain moved to the right lower quadrant of the abdomen where it persisted.

Upon examination there were found the usual signs of an acute intra-abdominal lesion in the right lower quadrant, rigidity of the abdominal wall, and tenderness both direct and rebound. Evidences of the sore throat—marked injection of the pharynx and tonsils—were still present.

FIG. 1.

Operation was performed immediately under gas-ether anæsthesia. The appendix showed extreme congestion with a sharp line of demarcation indicating thrombosis of the mesenteriolum. The peritoneum was markedly injected in the general region of the operation and as far as one could see. Considerable peritoneal exudate was present from which the bacillus coli communior was later grown in pure culture. The appendix removed and stump cauterized with carbolic acid. Two moderately stiff rubber tubes were inserted for drainage; one of these extended to the pelvis; the other was laid in the right lumbar gutter.

The patient made a satisfactory immediate recovery from the operation. Later the temperature rose from 102° F. to 104° F. and signs of localized consolidation in the right lung appeared on the second day. With the temperature going to 106° F. on the third day, the patient became irrational and pulled out both of the drainage tubes. One of these was immediately replaced in the wound, but it was impossible to be sure whether this occupied its original site, or even to determine its exact position particularly with reference to its proximity to the large pelvic vessels. In spite of the fact that during the next day or so there was a profuse discharge of pus through the replaced drainage tube, the patient's temperature continued around 106° F. On the fifth day he again pulled the tube out—and again it was replaced.

Four days later (nine days after the operation), bright blood was suddenly discovered to be oozing through the dressings. The patient was immediately brought to the operating room, the tube was removed and the old incision was extended for about a half inch in each direction. The presenting intestines were packed away and a large vessel, apparently the external iliac artery, was seen spurting blood into the wound. The bleeding was controlled by pressure with one finger and the vessel was isolated above and below the bleeding point. Stout catgut ligatures were passed

above and below and the vessel was tied on either side. A large tube was inserted into the wound and down into the pelvis.

At the end of the operation the right leg was found to be slightly congested and the pulsation of the dorsalis pedis artery of that side could not be felt.

Immediately after the operation the patient received an intravenous infusion of 600 c.c. of saline and a blood transfusion of about 250 c.c. In spite of these procedures, however, his pulse gradually became weaker and he died a few minutes later.

The post-mortem examination showed the following.

There was moderate distention of the abdomen. On opening the peritoneal cavity the intestines were found to be markedly distended and covered everywhere with a thin fibrino-purulent exudate. There was a collection of pus in the right lumbar gutter. The omentum was firmly adherent to the cæcum. The appendix stump was exposed by separating the adherent omentum. The ligature with which the appendix had been tied at the operation was not found and there was a small round opening into the cæcum corresponding to the point of attachment of the appendix. There was, however, no fecal leakage. The recently placed drainage tube passed close to the rim of the pelvis and in close proximity to the external iliac vessel. It passed directly down to the recto-vesical pouch, which contained a large amount of pus.

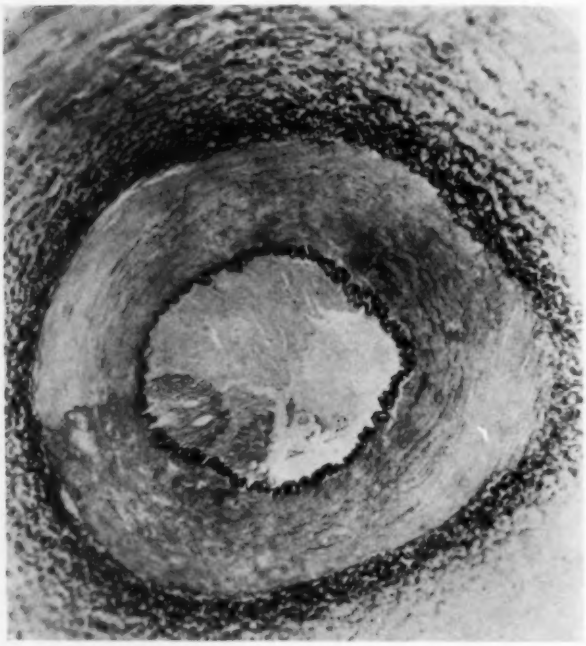

FIG. 2.

The right external iliac artery had been ligated in two places about a half inch apart, and at about the middle of its course. The peritoneum overlying the vessel in this particular spot had apparently been stripped away (operative exposure). Between the two ligatures there was a small longitudinal rent involving all coats of the artery.

The rest of the autopsy findings were essentially negative except for an acute bilateral broncho-pneumonia.

Microscopal sections were made of the vessel, above, through, and below the tear. The sections taken above and below the tear show a normal vessel wall. The section through the tear shows a complete rupture of the vessel wall without any apparent inflammatory process in any of the coats of the vessel.

CASE II.—Hospital No. 238594. The patient was thirty-four years old and was admitted to the hospital on the second day of an attack of acute appendicitis. There had been a typical onset with diffuse abdominal pain, radiating to the right lower quadrant with nausea, but without vomiting.

The physical examination demonstrated rigidity with direct and rebound tenderness in the right lower quadrant. No mass was palpable. The rectal examination was negative. The remainder of the physical examination gave no positive information of any kind.

Operation was performed immediately upon admission by Doctors Colp and Selig. The appendix was found to be bound around with inflamed omentum and was surrounded by an abscess. A fecolith lay free in the abscess cavity. The appendix was gangrenous and perforated. The inflamed omentum was resected and the appendix was removed in the usual manner. The abdominal wall was closed in layers, except for an opening through which a tube emerged from the abscess cavity.

Thirteen days after the operation the sutures were removed and the tube was shortened. On the sixteenth day there was a sudden profuse hemorrhage from the wound. The tube was removed and the wound was packed with gauze. Inspection of the wound a few hours later showed no active bleeding. Nevertheless the wound was repacked. The next morning, on removal of the packings, the hemorrhage was repeated. The patient was immediately brought to the operating room and the original incision was extended. (Operation by Doctor Wilensky.) A short section of the deep epigastric artery lay exposed in the wound margin and blood was seen to spurt from a small opening in the exposed portion of the vessel wall. About three centimetres of the injured vessel were resected between ligatures and the wound repacked with gauze. There was an uneventful recovery.

FIG. 3.

We are indebted to Dr. F. S. Mandlebaum, Pathologist to the Hospital, for the following notes of the histological examination of the excised portion of deep epigastric artery from the preceding case:

FIGURE 1.—Section of a medium-sized artery together with some perivascular tissue. The intima presents a normal appearance for about one-half of the circumference of the vessel. The remaining half of the intima is greatly thickened and protrudes into the lumen, converting the latter into a crescentic channel. This thickening of the intima is due to the presence in it of connective tissue, round cells, and fibroblasts. The endothelium is intact. The internal elastic lamina presents a normal appearance except for some thickening and loss of its wavy outline in the region corresponding to the thickening of the intima. The media is normal the adventitia shows some slight round cell infiltration and increased vascularity. The perivascular tissue consists of granulation tissue containing many capillaries, round cells, histiocytes, and a few giant cells.

FIGURE 2.—The Weigert elastica stain shows the internal lamina as described in Fig. 1. The above sections were made at a point removed from the site of rupture of the artery.

FIGURE 4.—A cross-section of the artery showing but very little normal structure. One-half of the circumference of the vessel is greatly thickened and bulges outward. Here the normal structure is entirely missing and is replaced by blood, fibrin, and numerous polymorphonuclear leucocytes. The remainder of the vessel is formed by thinned-out adventitia. The intima and media have been ruptured with a resulting suppurating aneurismal sac. Adjoining this area is thickened fibrous intima with the corresponding internal elastic lamina sharply ending at the point of the rupture of the vessel. The media presents a somewhat hyaline appearance. The surrounding fat and connective tissue shows acute and chronic inflammation with marked vascularity and many phagocytic cells. Accompanying the artery is a vein (not seen in photograph) the lumen of which is practically completely occluded. The elastic stain of this section (*Figure 5*) shows the abrupt disappearance of the internal elastic membrane at the site of the aneurismal formation and the thinned out adventitial tissue forming the wall of the latter.

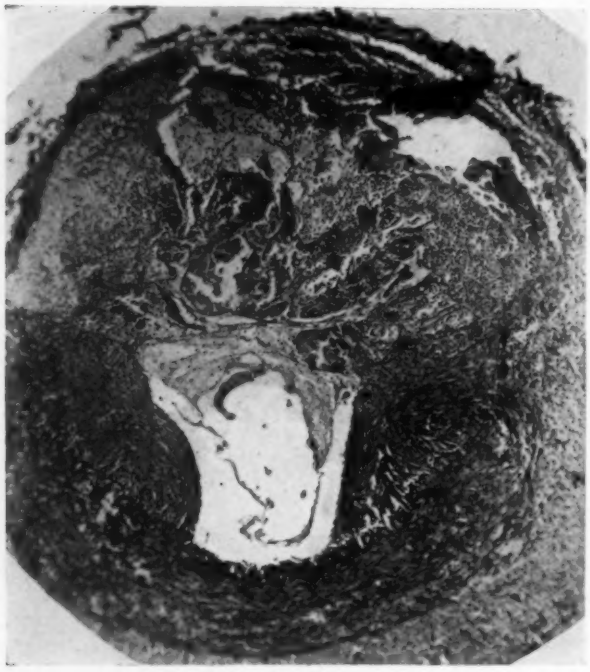

FIG. 4.

The microscopical sections of the excised portion of epigastric artery are extremely interesting and show the development of the lesion. Figures 1 and 2, the sections of the vessel taken at a point removed from the site of rupture, apparently show the early stages in the process. There is present a thickening of the intima on the side of the vessel adjacent to the drainage tract. At this stage the cells of the thickened intima are apparently in good condition and all of them appear distinctly viable. As we come closer to the actual site of rupture we see that the cells in the thickened portion are apparently undergoing necrosis. At this point we also note the beginning of the cleft in the vessel wall. (*Figure 3.*) This cleft extends through the intima and media, almost to the adventitia. Figures 4 and 5 are further stages in the process, showing the formation, practically speaking, of an aneurismal sac with subsequent rupture.*

Discussion.—The various factors involved in this accident are (1) trauma, (2) pressure by tube, or other drainage apparatus, and (3) infection.

1. *Trauma.*—It is difficult to make a decision as to the rôle the factor of trauma plays. As pointed out previously in this communication, the claim has been put forth that if the artery is covered by intact healthy peritoneum, no hemorrhage will occur from the underlying vessel. There is no experimental or other evidence available in the literature which can help in making

* We are indebted to Mr. Oneil, of the College of Physicians and Surgeons, New York, for the photomicrographs.

a decision as to this factor. There have been numerous opportunities of examining, post-mortem, drainage tracts reaching into the peritoneal cavity. In no one of these had there been any evidence of any agglutination or other abnormal relation between the overlying peritoneum and the underlying vessel. In the first of the two cases reported in this communication, the drainage tube had been pulled out on two occasions after each of which the tubes were replaced with a certain amount of difficulty. In this instance the post-mortem specimen showed that the vessel had become agglutinated to the parietal peritoneum in the immediate region of the drainage tract, and that the rent had occurred in the vessel in the centre of the agglutinated area. It is questionable whether the agglutination could, or would have occurred, spontaneously, and it does not seem reasonable to assume that it had something to do with the preceding trauma—pulling out and replacement of the tubes. The injury had probably resulted in a tearing of the peritoneum; subsequently exudate had formed in and around the rent, which had glued the vessel to its overlying peritoneum. Such pathology would predispose to the secondary bleeding.

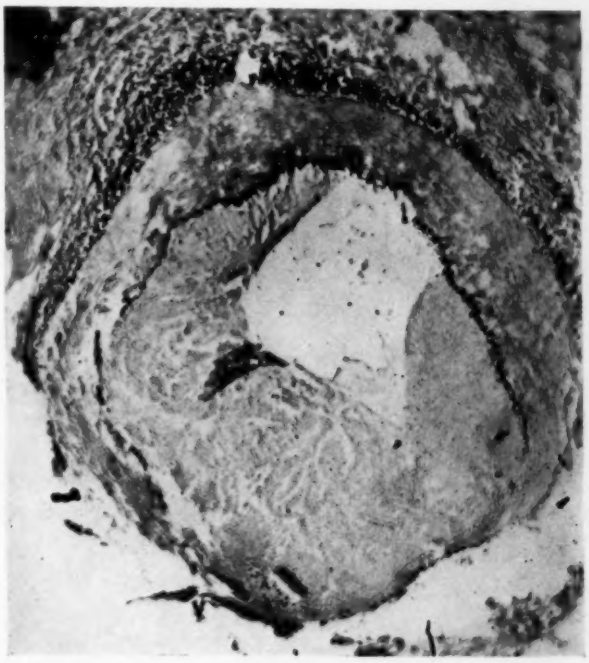

FIG. 5.

In our second case, apparently there was no gross trauma, either operative or accidental. Still in cleaning the wound during the daily dressings, and frequently this includes the temporary removal and replacement of the tube or tubes, there is abundant opportunity for microscopical, or even larger traumata in the inflamed scar tissue which lines the drainage tract.

2. *Pressure of Drainage Tubes.*—It is necessary to distinguish between the cases in which infection is absent, and those in which it is present. The pressure of the drainage tube causes pressure atrophy of the tissues in close apposition to it, so that the tissues forming the drainage tract accommodate themselves to the size, direction, and other physical characteristics of the tube.

We have never seen a vessel become exposed in the margin of an operative wound irrespective of the position this vessel occupies in the body—abdominal

cavity, extremity, etc.—when the wound conditions are those of an aseptic healing. If a vessel lie in close relation with a surgically aseptic drainage tract, some change necessarily becomes transmitted to it, but the degree of this change must necessarily vary in direct proportion with the thickness and character of the intervening tissues. The experimental work done upon dogs recently by Shoenbauer and Gold shows that the mere contact of rubber tubes with large pulsating vessels, such as the aorta, in uninfected wounds, causes, instead of atrophy or erosion, an actual protective thickening of the vessel wall at the point of contact. Microscopical sections of the vessels taken a few weeks or less after insertion of the tubes, showed at the point of pressure, proliferation of the intima and thickening of the media and adventitia.

When, however, the conditions of the experimental wound were other than that of aseptic healing, different results were obtained by Shoenbauer and Gold. When the elements of trauma or of infection or of both were added, perforation of the vessel could be produced.

Both of these pictures are illustrated in the sections of the vessel described in this communication. There is the initial thickening which, in accordance with the work of Shoenbauer and Gold, can be assumed to have a protective function. Then there is the subsequent infection with all the physical changes leading to the formation of an aneurism and the final rupture and hemorrhage. In an infected environment instances are numerous in which vessels become exposed in the margin of the wound; secondary bleeding is then a common phenomenon. Here, the thickness of the tissue between the surface of the wound and the subjacent blood-vessel is an important factor, and when the intervening tissue is of considerable bulk, the vessel usually remains covered and hemorrhage does not occur. The paucity of intervening tissue is especially to be noted in certain classes of operative wounds, notably in rectus muscle incisions in the abdominal wall and in incisions made for deep-seated infections of the forearm on its anterior aspect. In rectus muscle incisions this is aided by carelessness in planning the incision; if the incision in the peritoneum is made too close to the centre of the muscle, the deep epigastric vessels lie in much closer contact with the line of incision and with any introduced drain than if the peritoneal incision is made close to the outer boundary of the muscle.

The microscopical pictures of the second case described in this communication show that the mechanism causing the bleeding is that of a ruptured traumatic aneurism. In another instance—a case of infection of the forearm—this was proven; a definite aneurism actually formed and became visible; hemorrhage was prevented by ligation of the vessel above and below the aneurism with excision of the latter. I give the clinical and laboratory notes of the case.

Hospital No. 194280. On August 15, 1919 a patient was admitted to the hospital with a severe infection of the hand and forearm. Sometime previously he had suffered a laceration of the palmar surface of the hand; the latter had been sutured; later it became infected and as a result of this a lymphangitis appeared and spread upwards in the forearm and arm.

On August 18, 1919, a number of incisions were made into the anterior surface of the forearm by Doctor Moschcowitz. It was established that there was a purulent infection of the tendon sheaths in addition to the lymphangitis. The resulting wound was treated by the Carrel-Dakin method.

During the subsequent dressings, the Carrel tubes were changed a number of times. The wound had become partially necrotic and there was a considerable discharge of pus. At the beginning of September a small aneurismal sac was noted in the course of the radial artery and in order to prevent any secondary hemorrhage, the latter was excised between ligatures applied below and above it on the vessel. There was an uneventful recovery.

The specimen removed showed a definite aneurismal sac in the course of the radial artery. The sac wall was extremely thin and apparently on the point of rupture.

SUMMARY

The evidence appears strong that infection is the most important single factor, if it be not the only factor, causing secondary hemorrhage in operative and other wounds. The studies herewith reported show that the presence of the drainage apparatus causes an apparently protective thickening of the wall of the vessel with which the drainage material is in close contact; that this thickening is due to a proliferation of connective-tissue cells in the intima; that the infective process with resultant cell necrosis begins in the intima and spreads to the media; that a rupture occurs in the intima and media with the formation of an aneurismal sac; and that the bleeding follows as a result of the rupture of the aneurism. It seems, then, that in cases of secondary hemorrhage such as have been described, the important causative factors include an initial trauma of some kind, plus pressure of the tube or other drainage apparatus in an infected environment.

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FRACTURE OF THE LARYNX

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Although a search of the literature upon the subject does not reveal a very large number of reported cases of fracture of the cartilages of the larynx, Hofman,[1] having been able to collect only 124 cases, it seems that they are not of infrequent occurrence. Th. Patenka [2] convinced himself that they were met with quite frequently. That these fractures are uncommon enough to be of interest is probably due to the elasticity of the structures, the protection afforded by the lower jaw and the mobility of the larynx itself. There are, no doubt, cases of fissure or simple fracture of a single cartilage which are undiagnosed and are treated as simple contusions of the neck. Lane [3] reported nine cases of fracture of the larynx found in dissecting room subjects and stated, that after examining them, he came to the conclusion that the symptoms they produce are not always as severe or as characteristic as they are described to be, so that the injury itself escapes observation during the patient's lifetime.

Morgagni first described the condition, and several cases were incompletely reported by Malgaigne. The first accurate description was given by Gurlt [4] who reported sixty-eight cases, and G. Fisher,[5] in an interesting account, collected all of the cases recorded up to the year 1881. Harris [6] in 1895 stated that up to the year 1866 very little was known concerning these injuries. The accounts of Hunt,[7] Henocque,[8] and Durham [9] added materially to the statistics upon the subject.

The Mechanism and Pathological Anatomy.—The larynx is fractured more frequently in adult life, probably on account of the greater exposure to injury at this time and to the increased calcification of the cartilages. Cases do occur, however, even in early childhood. Hume [10] reports a fracture of the larynx in a child six years old, in which death occurred before anything could be done.

The time of calcification and later ossification of the cartilages is very variable, sometimes it is noted in early adult life and again it may not be present even in extreme old age. Dean [11] speaks of unusual calcification occurring in young persons and Shattock [12] mentions extensive ossification in the larynx of a dissecting room subject of middle age. On the other hand, Hunt [7] has noted a case of a man of 103 in whom the cartilage was very little ossified. The cuneiform cartilages, the epiglottis and the apices of the arytenoids being composed of yellow elastic cartilage, show little tendency to calcification, on the other hand the cricoid, thyroid and the greater part of the arytenoids, which consist of hyaline cartilage, become more or less ossified as age advances. Ossification commences about the twenty-fifth year

in the thyroid cartilage, somewhat later in the cricoid and arytenoids and by the sixty-fifth year these cartilages may be completely converted into bone.

Fracture may occur in any or all of the cartilages, but as a rule the thyroid is the one involved. Fisher [5] reports the following incidence in seventy-five cases:

Thyroid	29
Cricoid	11
Thyroid and cricoid	9
Hyoid and thyroid	3
Hyoid, thyroid and cricoid	2
Hyoid, thyroid, cricoid and trachea	1
Hyoid, thyroid and trachea	3
Trachea and thyroid	1
Cricoid and trachea	2
All parts of the larynx	14

The thyroid may fracture on account of its anterior angle being spread or compressed, the latter is, perhaps more frequent as blows are more often delivered from the side. Davis [13] stated that the fracture may be oblique, vertical or irregular, or involve only the cornua. The external perichondrium may rupture and the mucous membrane be torn or completely detached. Both wings of the thyroid may be flattened so that the internal outline of the larynx is distorted or obliterated.

Fractures of the cricoid and multiple fractures are usually accompanied by severe injury to the adjacent structures, thus determining the fatal issue so frequently seen in these types of break. Lockwood [14] reports a case in which death was due to a coincident crush of the vagus. The large vessels of the neck and the nerves may be hopelessly destroyed. If the cricoid breaks only in one place, it is usually behind; if in more than one place the breaks are scattered.

Either one or both arytenoids may be separated from their attachments to the cricoid, permitting relaxation of the vocal cords. In one of Hunt's [7] cases the right arytenoid was detached and in the case herewith reported both arytenoids were completely separated and their bases turned forward. Morton [15] said that combined fractures of the cricoid and the thyroid are rare and that fractures involving both the cartilages of the larynx and the hyoid bone are almost unknown. Interesting examples of this combined injury have been noted by E. Jaumaire [16] and J. E. Kelly.[17] Both direct and indirect force may act in producing these injuries. Gurlt [4] described two factors in their production by direct force.

First.—Compression from the side, as in strangulation, causing oblique fractures of the thyroid and double fractures of the cricoid.

Second.—Crushing of the larynx from front to back, causing oblique or vertical fractures.

Stoessel,[18] in an exhaustive study, describes the mechanism in the production of vertical fractures. The manner in which direct force may be exhibited is manifold; blows, kicks, flying objects and falls. It is interesting

to note how many of the reported cases were due to stumbling in the dark and striking the throat on the back of a chair.

Sokolowski [19] describes the interesting case of a peasant girl who had her apron caught in a reaping machine. According to the local custom she wore it on her back, with the strings tied in a knot in front. The tightening of the strings caused an oblique fracture of both wings of the thyroid. J. B. Berry [20] and T. B. Eastman [21] have noted cases caused by a piece of wood thrown from a circular saw. E. J. Moure [22] has told of a case due to the snap of a whip lash. Several interesting reports on the relation of these injuries to industrial accidents have been made, Gland Fils,[23] Dewatripont, L.,[24] Dupond, G.,[25] Lockwood, H.[14] having made studies in this regard. Several cases have been reported as caused by strangling, one by Kemper, G. W. H.[27] and one by Aubry, P.[28] In France, where garrotting was a common means of assassination, cases due to this form of direct violence are noted, and some very interesting studies on the medico-legal aspects of these cases have been made. Von Hofman,[29] De Aigre,[30] Couvin,[31] and in this country by Vinnedge, W. W.[32]

That indirect force can also cause a fracture of these structures is evidenced by the report of cases. It usually occurs in persons in whom there has been previous trauma to the larynx with subsequent necrosis or inflammatory change in the cartilages. A. W. DeRoaldes,[33] treated a case in a male, aged thirty-three years, who having accidently lodged an olive in his throat, attempted to produce vomiting and suddenly felt a cracking in his neck followed by local pain and disability, caused by a fracture of the left cornua of the thyroid cartilage. In one of Harris' cases the accident occurred while the patient was playing a musical horn. There was a crackling sound, pain in the right side of the neck, swelling, loss of voice and dysphagia, due to a fracture of the right cornua of the thyroid.

It has been stated by some writers that fractures of the larynx never occur from hanging owing to the position taken by the noose. Caspar, quoted by Ashhurst,[34] stated that it did not occur. However, a case is noted by Porter [35] of a fracture of the cricoid by hanging, and in the official report of the autopsy on the body of the assassin Guiteau, mention is made of wide separation of the hyoid bone and the thyroid cartilage, with rupture of the thyro-hyoid membrane, although nothing is said of a fracture. Morgagni wrote, "I have seen with Val Salva, a hanged man, who had the sterno-thyroidea and the hyothyroidea muscles torn, so that only a membranous substance remained in their place about the annular cartilage, and this very cartilage was broken asunder."

Associated with the fracture itself, as has been stated, the mucosa may be torn, permitting the air to gain access to the cellular tissues of the neck, with great swelling and emphysema. The cartilages may be fragmented and torn loose or displaced and there may be bleeding with the formation of submucous hæmatomata or flooding of the bronchi. There is a possibility of sub-hyoid and peri-pharyngeal abscess, necrosis of the cartilages and other inflammatory reaction in those cases due to direct force. In the compound fractures, and

indeed even in the slightest injuries, there is ever present the danger of infection of the respiratory tract with purulent bronchitis or broncho-pneumonia. Mediastinitis or cellulitis of the neck and submental regions may occur.

Stenosis of the larynx, adhesions of the vocal cords, and cicatricial narrowing of the glottis, due to the injury itself or to faulty treatment, may give rise to permanent alteration in the anatomy and physiology of the parts.

Symptoms and Signs.—St. Clair Thomson,[36] describes the usual symptoms as "local pain, tenderness and swelling, with more or less interference with phonation, mastication and deglutition." Hæmoptysis may occur and was regarded by Hunt as a particularly unfavorable sign as indicating that laceration of the mucous membrane had taken place. Pain is elicited by movement, swallowing and by handling the neck. Dyspnœa may be marked and of extreme urgency. Asphyxia with its attendant signs may appear early or occur later, even in those who appear quite convalescent, being in these cases probably produced by the displacement of a piece of cartilage or by sudden emphysema. Ecchymosis of the neck, with marked cyanosis of the face and upper part of the thorax may be seen.

Manipulation of the larynx may disclose a fissure, show displacement, mobility of the fragments or crepitus, which should not be confounded with that produced by the normal larynx gliding over the anterior surface of the cervical vertebræ.

Laryngoscopic examination may reveal a pale œdema, or redness and swelling, congestion or hemorrhage, and show to what extent respiration is interfered with. The false bands may be found to be reddened and swollen to a prodigious degree, causing stenosis of the glottis. The upper portion of the thyroid cartilage may be seen to be flattened and pushed into the larynx, or completely detached portions of cartilage may be seen. Bleeding points, tags of membrane or foreign bodies may be discovered.

Emphysema of the neck is a very serious symptom that is quite likely to supervene, the air gaining entrance through a tear in the mucosa and expanding the cellular tissues. It may extend to the tissues of the face, thorax, back, arms and abdomen, as mentioned in a case of Hawthorne.[37] An instance has been remarked by Middleton,[38] with extensive emphysema, wherein the pericardial fat as well as that of the mediastinum was loaded with air, so that it had a swollen, sponge-like appearance. In Humes' case the emphysema was so great that there was compression of both lungs. Tilleaux [39] tells of a curious case of swelling of the soft palate following a fracture of the larynx. Crepitation appears early and may rapidly extend. The symptoms, one or all, with varying degrees of disability, may appear at once, or may be delayed for some time, even until after the patient has regarded the injury cured. Morganthau [40] mentions the case of a man who presented himself three weeks after the infliction of an injury, seeking treatment for hoarseness. Barling and Wilson [40] mention that of a man who came to them sixteen days after being injured, complaining of pain, hoarseness and dysphagia, and others have noted instances in which the symptoms did not become of sufficient

gravity to cause the patient to seek surgical aid for periods varying from six to fourteen days. On the other hand, it is not uncommon for symptoms of the utmost urgency to make their appearance with almost fulminating rapidity and progress to a fatal issue before anything can be done.

Prognosis.—Agnew stated that every case was one of the most serious nature, and cautioned great reserve in venturing an opinion as to the final outcome. That these injuries have been attended by a high mortality in the past is shown in the figures given by Durham and quoted in Holmes System of Surgery; death occurred in 88 per cent.; Albert's series showed 80 per cent. mortality, Fisher's 78 per cent.; and Gurlt's 70 per cent. In thirty cases Harris states that in five where the cricoid was fractured the mortality was 20 per cent., where the thyroid was fractured, 20 cases, death occurred in 20 per cent. and in five cases of multiple fracture 60 per cent. died. These data of Harris throw some doubt on the statement that fractures of the cricoid are invariably fatal. Roe.[42] In one of Lane's cases before mentioned, there was a healed fracture of the thyroid and cricoid, which had nothing to do with the death of the person. Mansucci, B.,[43] and Major, F.,[44] have both reported cases of fracture of the cricoid in which recovery occurred. Death is, as a rule, due to interference with respiration, and it may occur within a few moments, Chauvel,[44] Story, G. B.,[46] or may be delayed for some time, Knaggs.[47] When occurring at the latter period, death is usually due to infection or pneumonia. In the event of recovery it is quite possible that the voice will be permanently altered, Packard, J. H.,[48] and hoarseness may persist for a very long period. It may be necessary to permanently wear a tracheotomy tube, owing to stenosis of the larynx, adhesions of the vocal cords, or cicatricial contraction. Shields.[49] These sequlæ can, however, be minimized by a proper attention to detail in the after-care. Practically all cases of laryngeal stenosis can be cured by laryngostomy.

Treatment.—Undoubtedly in those cases where there is no deformity or depression of the fragments, no hemorrhage, emphysema, swelling or dyspnœa, where laryngoscopy reveals no encroachment on the lumen of the larynx, expectant treatment is attended by satisfactory results in a certain number of instances. Under these circumstances the patient should be placed in a quiet room, in an atmosphere kept warm and moist. Complete silence should be enjoined, all efforts to use the voice being absolutely forbidden. Communication with the nurse or attendants may be had by means of a pad and pencil. Abstinence from food for a few days, nourishment and fluid being supplied by rectum. Under all circumstances very careful surveillance should be maintained. The attending surgeon should hold himself in readiness to deal promptly and decisively with any untoward development. Manby[50] records the case of a patient treated expectantly in whom there suddenly developed, on the third day, very urgent dyspnœa. Tracheotomy was resorted to and after a few days of storm the patient recovered. In the same vein, LeJars[51] quotes Atlee,[52] who has told of a case in a child, who striking his neck against an iron boot scraper, had a transitory attack of suffocation. Some

time after while sitting quietly by his mother, breathing normally, without any apparent signs of serious injury, he suddenly threw himself violently backwards. An enormous swelling appeared in the neck, spreading rapidly over the head, back and upper extremities, death occurring in a few moments. Hektoen [53] tells of a case expectantly treated in whom sudden death occurred from œdema of the glottis. These instances impress one with the need of constant watchfulness. In the more urgent cases where the patient is seen soon after the accident, and is shocked, perhaps unconscious, with the face swollen and purple, the skin cold and the pulse feeble, the neck distended with a tympanitic, crepitating swelling which extends from the jaw down over the chest and may be visibly enlarging, immediate tracheotomy is demanded. (Marcigny.[44] Eastman.[21]) The immediate indication is to free the air passage and it should be done at once and with any possible instrument as best it can. Tracheotomy under these circumstances may be difficult, and when performed on a neck swollen and distended with blood and air, with landmarks obliterated and on a struggling patient, it is not the simple procedure that it is under circumstances less urgent. LeJars [51] graphically described the operation under these conditions. Chevalier Jackson [55] has recently written on the operation of tracheotomy and advises in all circumstances a low tracheotomy in order to prevent laryngeal stenosis. In the event that the trachea has to be opened high, he warns against wearing a tube in the high position, but states that a second more deliberate opening should be made lower down for the insertion of the tracheotomy tube. He states that the operation of tracheotomy is much simplified by splitting open the entire front of the neck exactly in the midline, so as to obtain a large wound in which to feel for the trachea.[59] After the trachea is opened and a passage assured, it may be advisable to aspirate the tracheo-bronchial tree in as far as is possible by introducing a rubber catheter through the cannula and drawing out the blood and mucus with the aid of a syringe or bulb. Letarget [56] tells of a case so treated. After tracheotomy the patient appeared to be beyond help. Aspiration was performed by attaching a rubber bulb to a catheter and a vacuum maintained. The tube was slowly withdrawn and a clot six inches long was found attached to the end of it. This was repeated five or six times, each time with the same result. Respiration began, cyanosis disappeared, and the man went on to recovery. A slender copper tube attached to a mechanical aspirator such as is used in nose and throat operations, is more efficient; and a small bronchoscope and forceps may be required for firm clots. (Jackson.[60]) Artificial respiration may have to be resorted to after the passages are clear and the condition should not be regarded as hopeless until this has been continued for some time without success. Bronchoscopic oxygen insufflation is invaluable after bronchoscopic clearing of the airway. (Jackson.[59, 60]) General anæsthesia should be avoided, but in the event that it is necessary, the intratracheal method will insure the patient's safety and greatly facilitate the work of repairing the injured structures. After the air passages are open and the respiration established, one should undertake to repair the damaged

tissues. A laryngo fissure may be performed and the traumatized tissues deliberately inspected and repaired. Displaced pieces of cartilage with intact blood supply may be replaced, blood clots removed, bleeding points ligated and lacerated mucous membrane repaired by suture. The suture should carefully approximate the torn margins without strangulation so as to avoid as much as possible death of the tissue and subsequent scar formation. Displaced cartilage may be fixed in position by suture as in a case reported by Briddon,[57] though as a rule the thyroid cartilage holds sutures badly. (Chevalier Jackson.[59, 60]) The arytenoids may be replaced and secured by suture. If oozing of blood persists, the cavity of the larynx may be packed with gauze and the air current assured through the tracheotomy opening. The external wound should be carefully sutured in the anatomical planes and proper drainage established. The tracheotomy wound should not be sutured but lightly packed with gauze. The dressings must be changed hourly and the utmost care taken to prevent the accumulation of tissue fluids and saprophytic organisms in the highly infected secretions from this type of wound. Douning and Boularin [58] have written upon the indications for suture of the larynx and trachea. Jackson [55] states: "The tracheotomy tube must be of the proper size and shape and material, and without fenestrations. Rubber and aluminum should not be used. The inner cannula should be cleansed hourly or oftener. The outer cannula should be removed at least once a day, cleansed, smoothed, polished, sterilized and fitted with clean tapes. For this daily toilet duplicate cannulæ should be provided." The cannula should be removed at the earliest possible moment, it should be partially corked (Jackson,[59, 60]) for a gradually increasing period of time on several days before it is completely removed, since as it is much easier to breathe through the neck the patient may resist all efforts at removal of the cannula. After operation the patient should be kept in a warm, moist room, silence enjoined and small doses of morphia and atropine administered to combat restlessness and limit as much as possible the amount of secretion. After the tube is removed and the wound healed, further intervention may be needed for the cure of strictures of the larynx, adhesions of the vocal cords and narrowing below the glottis. "If cicatricial stenosis is impending, it is better to do a laryngostomy at once. (Jackson.[59]) This procedure consists of splitting the thyroid cartilage in the midline; and the wearing of, first a pack, then a rubber tube in the larynx supported on a laryngostomy cannula, instead of the ordinary tracheal cannula, until the interior of the larynx is epidermatized with epidermal epithelium and the larynx is converted into an open trough. This requires many months of treatment during which the apparatus must be changed daily, and the size of the rubber tubing must be increased from time to time. As shown by Gabrial Tucker, the best way to increase size smoothly and evenly is to slip a rubber glove finger over the tubing. The open trough is closed by a plastic operation after a six months' test period has demonstrated that the laryngeal stenosis will not recur." (Jackson.[59, 60, 61])

CASE I.—A male laborer, age twenty-three, had his throat caught between an elevator gate and an elevator sustaining a compound fracture of the larynx. Was badly shocked when first seen and was unable to speak. Immediately below the mandible there was a lacerated wound extending from the angle of the jaw on right, around to the angle on left, the soft tissues were stripped from the mandible exposing the bone for its full length. Large vessels were not damaged. Tissues of the neck and face were emphysematous, emphysema visibly enlarging. Respirations labored and difficult.

Operation: August 10, 1915. A high tracheotomy was performed and the larynx opened through a vertical incision. The thyroid cartilage was comminuted. The arytenoids were broken off from their attachments at the base and the vocal cords relaxed. There was free bleeding from the lacerated mucosa. The fragments of the thyroid cartilage were sutured with fine catgut approximating the edges, but not overlapping. The arytenoids were fixed in place by means of three sutures of catgut. Then a low tracheotomy was done and the wound of the high tracheotomy and in larynx closed by suture. All bleeding carefully controlled by ligature and the large wound in the neck closed by suture in layers. The wound was drained with rubber strips extending to its depth, and the skin was then partially closed. Intratracheal anæsthesia—ether.

August 18, 1915. Condition good. Wound draining freely. Tube changed hourly, cleansed and replaced.

September 5, 1915. Tube removed and allowed to remain out. Very little air escaped through wound. Tube had been closed for varying intervals on several previous days. On two occasions during following few days had severe attack of dyspnœa and it seemed imperative to again replace the tracheotomy tube. Larynx cleansed with sodi Bicarb. solution and 5 per cent. cocaine, after which he was much easier and had no more difficulty in breathing.

September 25, 1915. Discharged, good condition, no dyspnœa. Voice hoarse but understood at distance of several feet.

Two years later.—No difficulty in breathing, but voice hoarse and husky.

CASE II.—Adult male, thirty years of age, struck in throat by piece of wood thrown from a saw. Shocked, dyspnœa and cyanosis, crepitating swelling from mid-sternum up to eyes and extending back over neck and occiput. Pulse 110, small and thready. Skin not broken.

October 12, 1917. Immediate operation. Local anæsthesia, 1 per cent. novocain, infiltration. Low tracheotomy done and tube inserted. Cyanosis cleared and patient brightened. The right thyroid cartilage was fractured obliquely and comminuted. The crepitation was marked when larynx was grasped between fingers. Laryngeal fissure was done and interior of larynx inspected. A small piece of cartilage had been forced through mucosa. This was removed and rent sutured with fine chromic catgut. The fragments of cartilage were held in position and secured by several sutures of fine chromic catgut, and wound in neck closed in layers without drainage.

Tracheotomy tube removed in twelve days. Emphysema subsided. Tube replaced temporarily twice the following day and permanently removed on the fourteenth day. Wound closed by first intention. No complications. Voice husky but improving when seen three months after discharge.

CASE III.—In July, 1918, there was brought into my service at the American Ambulance in Paris, a soldier who had been struck in the neck by a spent piece of shell. Pain had been severe but subsided and when seen by me twenty hours after injury his only symptoms were moderate dyspnœa and marked swelling of the front of the neck. He was watched for sudden symptoms and taken to operating room a few hours after admission. While waiting for anæsthesia to begin he expressed a desire to sit up. After a few moments, feeling better, he assumed recumbent position. After only one or two whiffs of ether he suddenly became cyanosed, swelling of neck increased and death occurred in a few moments in spite of immediate tracheotomy and continued efforts at resuscitation.

Autopsy revealed a fracture of the thyroid cartilage, compound into larynx, with an area of infection about the wound, and great infiltration of the cellular tissues of the neck.

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TRAUMATIC FAT NECROSIS OF THE FEMALE BREAST AND ITS DIFFERENTIATION FROM CARCINOMA*

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A THIRD REPORT FROM THE MEMORIAL HOSPITAL

In May, 1920,[7] we presented before the American Surgical Association our first report upon Traumatic Fat Necrosis of the Female Breast. The object of this communication was to establish the condition as a new clinical entity and to point out the striking similarity of this hitherto unrecognized tumor to carcinoma of the breast. In May, 1921,[8] we had collected three additional cases from the Breast Clinic of the Memorial Hospital, and a further report was made. Since that time four additional cases have appeared in the Clinic, and Bloodgood, of Baltimore, Kilgore, of San Francisco, and Hyman and Berg, of New York, have kindly permitted us to include unpublished cases of their own in the present series. Meanwhile, Cohen and Parsons in America and Stulz and Fontaine in France have each published an additional case. The present paper represents an effort to place on record all authentic cases, with some additional considerations concerning the clinical and pathological features of this disease.

Nature of the Process.—Fat necrosis is a disintegration of fat cells with the associated tissue reactions of new connective tissue formation and the production of foreign body giant cells. For many years, fat necrosis has been most frequently encountered as the acute necrosis of fat in the omentum and mesentery secondary to acute pancreatitis. These changes in fat tissue have been produced by the pancreatic fat-splitting ferment, and the lesions may be easily reproduced experimentally as Opie [9] Wells,[13] and Langerhans [5] have shown.

Similarly, we have all recognized that fat necrosis may appear in subcutaneous tissue following trauma. In new-born babies the trauma of a difficult instrumental delivery sometimes produces a tumor having the identical microscopical picture of fat necrosis of the breast. Occasionally surgeons encounter fat necrosis of subcutaneous tissue secondary to a hypodermic injection, or some other form of trauma, and a similar appearance may be found at times along an old healed suture line. Farr [2] reported several such cases and further produced these lesions experimentally in fat pigs.

Although the gross and microscopic picture of traumatic fat necrosis occurring in subcutaneous tissue in other parts of the body closely resembles that occurring in and about the breast, these lesions are far less important clinically than the particular condition we are describing. The clinical prob-

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lem of traumatic fat necrosis of the breast is an important one, for this condition must be considered in properly differentiating tumors of the mammary gland. The process often seems progressive for a time, resembling a true tumor growth, and the close simulation to carcinoma of the breast makes it additionally important from the clinical standpoint. In the breast the great bulk of fatty tissue permits after trauma the formation of a tumor of some size, the largest mass encountered in the present series being 7 cm. in diameter.

Stulz and Fontaine [12] in September, 1923, in reporting a personal case, also included in their paper, cases reported by Lanz in 1882, Berner quoted by Heyde in 1911, and Kuttner in 1913.

In the Lanz and Kuttner cases the masses of fat necrosis were situated in the subcutaneous tissue overlying the breast, and Case IX of our own series, as well as Case XIII, also showed a similar involvement of subcutaneous tissue. The clinical appearance of these subcutaneous tumors overlying the breast is practically identical with the signs elicited when the fat necrosis is more deeply placed within the breast tissue. The cases of traumatic fat necrosis occurring in and about the breast may therefore be classified in one of two groups, namely:

Group A.—Tumors actually occurring within the breast.

Group B.—Tumors occurring in subcutaneous tissue overlying the breast.

In Group A, from our personal series and the literature, there are sixteen cases, namely:

Cases 1 to 8 (personal series)	8
Cases 9 to 12 (personal series)	3
Case 14 (personal series)	1
Case of Berner, quoted by Heyde	1
Case of Cohen	1
Case of Stulz and Fontaine	1
Total of Group A cases	15

In Group B, there are five cases, namely:

Cases 9 and 13 (personal series)	2
Case of Lanz	1
Case of Kuttner	1
Case of Parsons "	1
Total of Group B cases	5

The French authors mentioned object to our term " traumatic fat necrosis," proposing as a substitute " granulome lipophagique traumatique." We believe this term is a poor one, for the word " granuloma " is associated with the idea of infection, which apparently has no part in the production of this lesion. Upon the other hand, traumatic fat necrosis of the female breast is a disintegration of fat cells caused by trauma, with resultant necrosis and associated connective tissue reaction and the production of foreign body giant cells. Therefore, the term " traumatic fat necrosis of the breast " appears to be the proper one and more truly descriptive of the disease.

The difficulty in differentiating this tumor grossly and microscopically has been described below by Dr. James Ewing.

DIFFICULTIES OF PATHOLOGICAL DIAGNOSIS IN THE DIFFERENTIATION OF TRAUMATIC FAT NECROSIS OF THE BREAST FROM CARCINOMA

"The gross appearance of the lesions in fat necrosis resemble in many respects that of carcinoma, and in some cases it is difficult to distinguish between the two conditions. In both there is often the same firm induration which is readily explicable because the induration is caused by growth of new connective tissue which is progressively cicatrized.

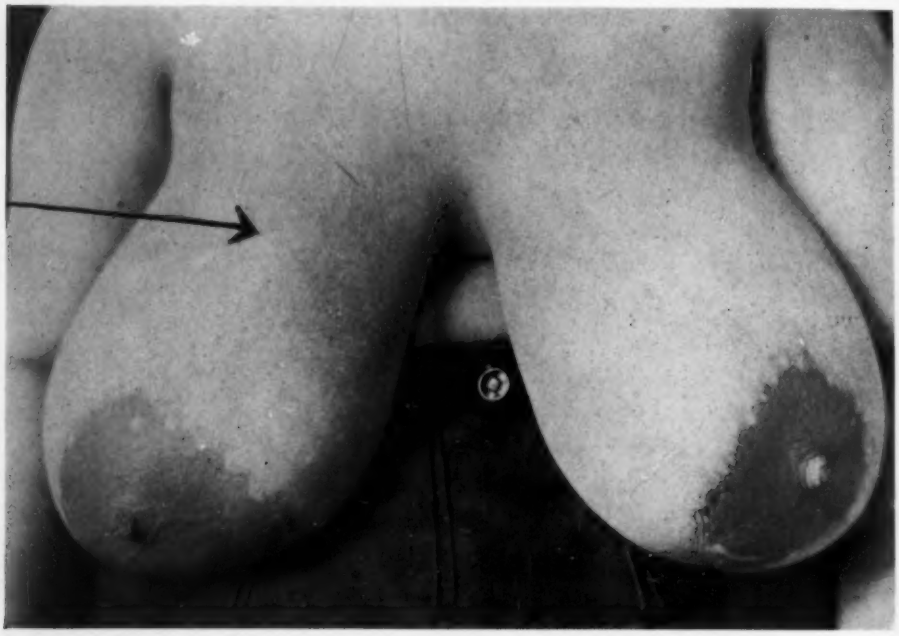

FIG. 1.—Case III. Breast lipomatosis. Breast reaches to umbilicus. Patient's weight 191 pounds.

From a consideration of microscopic structure the induration should be greater in infiltrating carcinoma. The outline of the gross lesion in carcinoma is generally much sharper than in fat necrosis, which may fade off gradually into surrounding areas. Chalky points and streaks of fatty epithelium lying in firm translucent connective tissue are characteristic of infiltrating carcinoma. The same whitish points are present in necrotic or inflamed fat tissue, but they are generally much broader and more irregular. Occasionally one finds a whole fat lobule as large as a bean, chalky and opaque from the proliferation of fat cells, in inflamed fat tissue. Carcinomatous nodules in the breast are nearly always single, whereas traumatized fat is often very irregularly distributed and cicatrization appears in multiple points. In fat necrosis the new connective tissue is much more translucent than in carcinoma and often it is of a faint reddish color from the presence of fine capillaries, which are absent in carcinoma. Later, cicatrization obliterates these capillaries and the connective tissue of fat necrosis becomes as dense and opaque as in carcinoma.

"In a recent case of supposed fat necrosis, a firm resistant area 2 cm. wide was encountered in a lipoma of the breast. The opacity and chalky streaks of carcinoma were missing, but a correct diagnosis of carcinoma was made on the very firm induration, rather sharp borders, and on transmitted light, the marked opacity of the lesion. In

another very puzzling case, fat necrosis was recognized by the presence of two outlying fat lobules which presented broad opaque spots of proliferating fat cells. The central position of the lesion strongly resembled carcinoma. However, one must be prepared to meet both carcinoma and traumatized fat tissue in the same breast. But why not resort at once to frozen sections? The reasons are that one must previously choose on gross examination the tissue to be sectioned, and when frozen sections are made the diagnosis may still be difficult.

"The microscopic structure of inflamed fat tissue in the breast strongly resembles alveolar carcinoma, especially in the later fibrous stages, when one encounters proliferating fat cells almost exactly reproducing the small alveoli of carcinoma lying in cicatricial

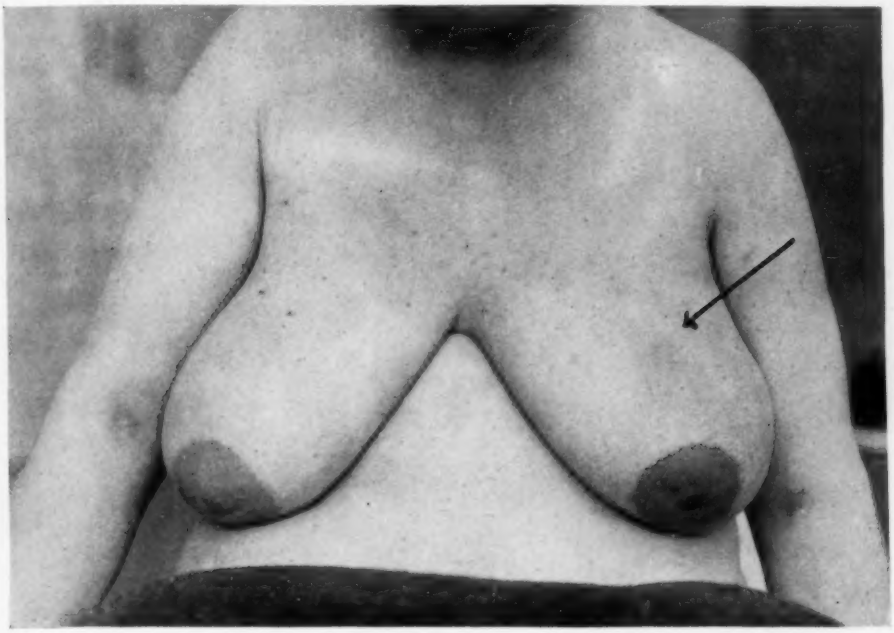

FIG. 2.—Case VI. Arrow points to discoloration, (duskiness) of the left breast. Patient's weight 196 pounds.

connective tissue. So complete is this resemblance that an expert microscopist may have difficulty in distinguishing between the two conditions. In frozen sections this difficulty may be practically insuperable, and there is little doubt that errors in the diagnosis of mammary cancer have occurred from this source. Usually the microscopic section furnishes a correct interpretation at once from the presence of much cellular overgrowth, fibroblasts mingled with lymphocytes, empty spaces once filled with fluid fat (oil cysts), formation of many phagocytic giant cells (Figs. 13 and 15), and wide areas of proliferating fat cells.

"In fibrous stages more reliance may be placed on the general lack of activity and lack of hyperchromatism in the cells. From some forms of cellular carcinoma with secondary degeneration and rich infiltration by lymphocytes, fat necrosis may be distinguished only by the exercise of great care. Wide sheets of polyhedral proliferating fat cells may almost exactly reproduce portions of cellular so-called "Medullary" carcinoma. The best paraffin sections are called for in this work."

The clinical history, physical findings and pathology of Cases I, II, III, IV and V have been described in previous communications of the authors.[7, 8]

The following four cases have entered the Breast Clinic at the Memorial Hospital during the past two years:

CASE VI.—I. H., married, female of forty-eight years. Was admitted April 23, 1923, complaining of a lump in the left breast. (See Fig. 2.)

Mammary History.—Five months before admission, while carrying a picture frame under her left arm, she fell headlong down a flight of stairs, landing eight steps below. As she struck the stairs, there was an impact of the corner of the frame against her left breast, causing a pain of such severity that she fainted. Almost immediately swelling and ecchymosis appeared at the site of the injury. The patient consulted her physician who

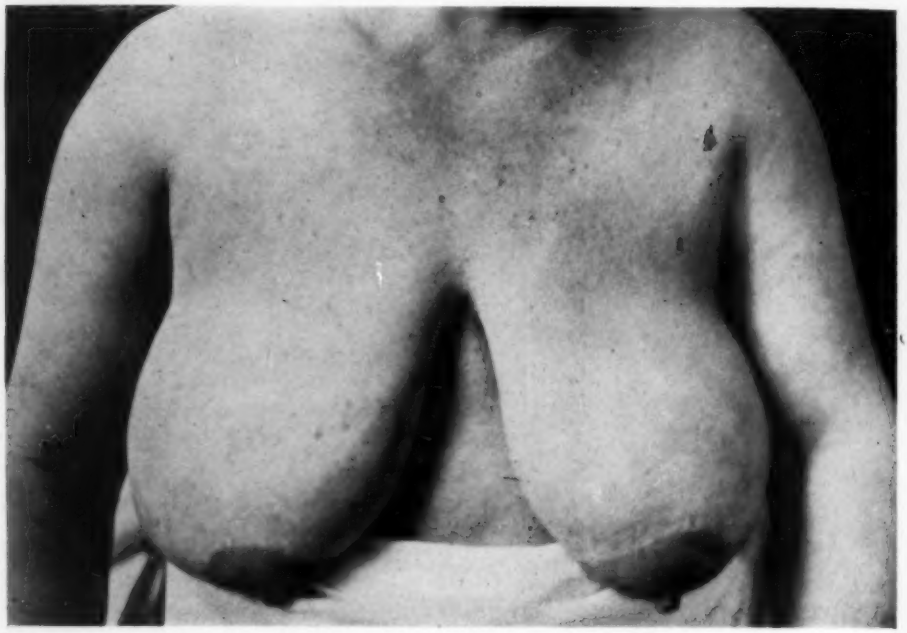

FIG. 3.—Case VIII. Short heavy woman of 160 pounds.

told her "a blood-vessel had burst." The major part of the swelling was present for a month, with gradual diminution in size, leaving a lump in the breast that had persisted to the time of admission. The "black and blue" area gradually increased in size until it involved the entire breast and a portion of the adjacent lateral chest wall below the axilla.

Physical Examination.—The patient was an obese woman in good general condition. Her weight was 196 pounds. General examination was negative.

Breasts.—Over an area 7 cm. in diameter, the skin of the upper inner quadrant of the left breast had a slightly brownish discoloration. The skin was definitely attached to a deep-lying tumor situated 15 cm. above the nipple level and measuring 6 x 8 cm. The entire breast and tumor moved freely on deeper structures. The tumor was hard though somewhat resilient and in two portions the edges were sharply defined. There was no retraction of the nipple. In both axillæ large moderately firm nodes could be palpated. No supraclavicular nodes were palpable.

Provisional Diagnosis.—Attention was directed especially to diagnosis of traumatic fat necrosis because of the type of breast and the accurate history of trauma.

Operation.—Under one-half per cent. novocaine, the tumor was excised, going well beyond its circumference. On section there was no evidence of malignancy. The wound was closed save for a small split within tube.

Pathology.—Report by Dr. James Ewing. "Area 3.5 x 1.5 x 1.5 cm. (See Fig. 7) beneath the skin which is adherent by fibrous strands, is opaque yellowish and brown, with small cysts fading into fat tissue, and showing some whitish new tissue about parts of the lesion. Sections (No. 6859) show a great variety of processes connected with fluidification and necrosis and absorption of fat; and the reactive productive inflammation which accompanies them. Giant cells of very large size are very numerous and form large sheets lying between streaks of new connective tissue. There are many small oil cysts surrounded by lenticular giant cells. Some areas show beginning liquefaction and necrosis of fat. The amount of new connective tissue is moderate. Everywhere there is infiltration with hemorrhagic detritus, and about the periphery of the lesion are many very heavily pigmented cells. Areas of proliferating fat cells give an appearance not unlike carcinoma."

FIG. 4.—Case IX. Breasts unusually heavy in comparison to remainder of body. Weight 186 pounds.

Post-operative Course.—The post-operative course was uneventful, the patient being discharged from the hospital one week after operation.

CASE VII.—J. N. (See Fig. 5) married, female of forty-four years, was admitted to Memorial Hospital, July 3, 1923, complaining of a lump in the right breast.

Mammary History.—Patient had had a painful sensation in the right breast appearing intermittently over a period of many years. About eight years previously she was under observation in the Memorial Hospital for a time on account of these breast symptoms, but no tumor was then present. Two weeks before admission she noticed some retraction of the right nipple and upon palpation felt a lump in the right breast. There was no history of trauma to the right breast.

Physical Examination.—Patient was an obese woman in good general condition. Her weight was 181 pounds. There was slight systolic murmur over the precordium. At the basis of the lungs occasional crackling râles could be heard.

Breasts.—The breasts were very large and fat. Above the right breast near the third costal sternal junction was a scar of a former burn. The right nipple was elevated and retracted. There was no skin adherence. Situated in the mid-portion of the right breast slightly above the nipple level, was a hard mass measuring 5 cm. in diameter. There was no attachment to chest wall. Neither axillary nor supraclavicular nodes were palpable. The opposite breast was negative.

Provisional Diagnosis.—Because of the stony hardness of the tumor, and the elevation and retraction of the nipple, we felt that we were dealing with an early carcinoma of the breast. The chest plate was negative for metastasis to the lungs. A pre-operative, low

voltage X-ray cycle of five treatments was given over the breast, axilla and supraclavicular regions.

Operation.—We were so certain that the case was one of mammary cancer that a radical breast amputation with removal of muscles and axillary contents was performed.

Pathology.—Report by Dr. James Ewing. "The process consists of a chronic inflammation in fat tissue, but no signs of carcinoma can be found. The tissue shows small areas of partly liquefied and saponified fat, which is granular, amorphous and bluish staining. About these areas there is very active growth of cellular connective tissue and granulation tissue in which many rather hyperchromatic spindle cells are found.

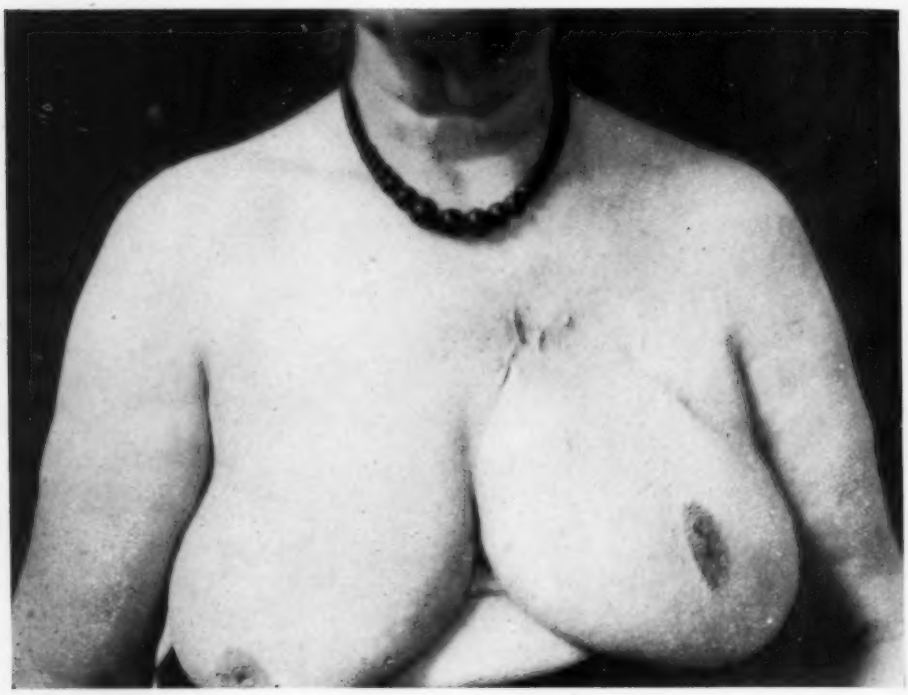

FIG. 5.—Case VII. Weight 181 pounds.

Among these are many giant cells of small and large size, some inclosing small masses of fat. Just about the areas of fluid fat the cells are large and polymorphonuclear. There are no signs of carcinoma. The whole area of fat necrosis covers about 3 cm."

Post-operative Course.—The post-operative course was tragic. During the operation the patient had taken the ether poorly, as shown by frequent obstruction to air passage with consequent cyanosis. However, she left the operating room in good condition. Three hours later the patient was again cyanosed, had Cheyne-Stokes respiration and could not be aroused. Stimulation was strenuously applied and artificial respiration kept up for an hour and a quarter, but without avail. Death was probably due to cardiac decompensation. No autopsy was permitted.

CASE VIII.—S. S., married, female of thirty years, came to the Memorial Hospital, July 9, 1923, complaining of a lump in the right breast.

Mammary History.—(See Fig. 3) Had had three lactations, each lasting almost seventeen months, the last one occurring two years before admission to the hospital. Approximately three months previously the patient first noted a small lump in the inner aspect of the right breast. The mass increased in size and was slightly painful. There was no history of trauma and lues was denied.

Physical Examination.—The patient was a short corpulent woman. The chest examination was negative except for a systolic apical murmur which was not transmitted. Her weight was 160 pounds.

Breasts.—The breasts were large, soft, fat and pendulous. The nipples protruded and were on the same level. Along the mesial portion of the right breast there was a tumor 5 x 3 cm., which was firm, but not as hard as carcinoma. Skin was not attached to the tumor. There was no nipple retraction. One small node could be palpated in right axilla.

Provisional Diagnosis.—We believed that we were dealing with a benign tumor, but on account of its firmness malignancy could not be excluded. Therefore, we decided to do

FIG. 6.—Case IV. Shows the adherence of the tumor to the overlying skin. In this case the nipple was pulled downward toward the chest wall. The skin adherence and pulling of the nipple exactly simulated carcinoma.

a local excision of the tumor including a wide surrounding zone, basing further procedure upon the gross appearance of the section.

Operation.—July 20, 1923. Ether anæsthesia. A wide excision of the tumor was made. The mass was partly composed of a smoothly lined cyst 7 x 5 cm. In one portion there was a projection of necrotic brown tissue into the cyst. From the cut lactiferous ducts there exuded a thick yellow creamy material. Gross examination revealed no evidence of malignancy.

Pathology.—By Dr. James Ewing. "Section shows a very active inflammatory reaction about liquefied fat. There is very extensive proliferation of fat cells producing areas in which these polyhedral cells, resembling cancer cells, are found in solid diffuse sheets. There are some points of liquefied fat about which giant cells form. On the periphery of the lesion there is much new growth of connective tissue. There is no sign of carcinoma."

Post-operative Course.—The patient made an uneventful convalescence.

CASE IX.—A. G., married, female of forty-five years, was admitted to Memorial Hospital, November 23, 1923, her only complaint being the presence of a lump in the left breast.

Mammary History.—(See Fig. 4) Patient stated that about four weeks before she accidentally noticed a lump in her left breast. It had remained stationary in size and was entirely painless. She had never received a severe trauma to the breast.

Physical Examination.—Patient was a corpulent woman in good general condition. Her weight was 186 pounds. Except for the breast tumor her examination was negative.

Breasts.—Situated 2.5 cm. from edge of areola in the direction of five o'clock from the nipple, was a stony hard tumor measuring 1.5 x 1 cm. The mass was just beneath the skin to which it was distinctly attached. The nipple was slightly retracted and definitely elevated. Throughout the entire breast there was a condition of chronic mastitis.

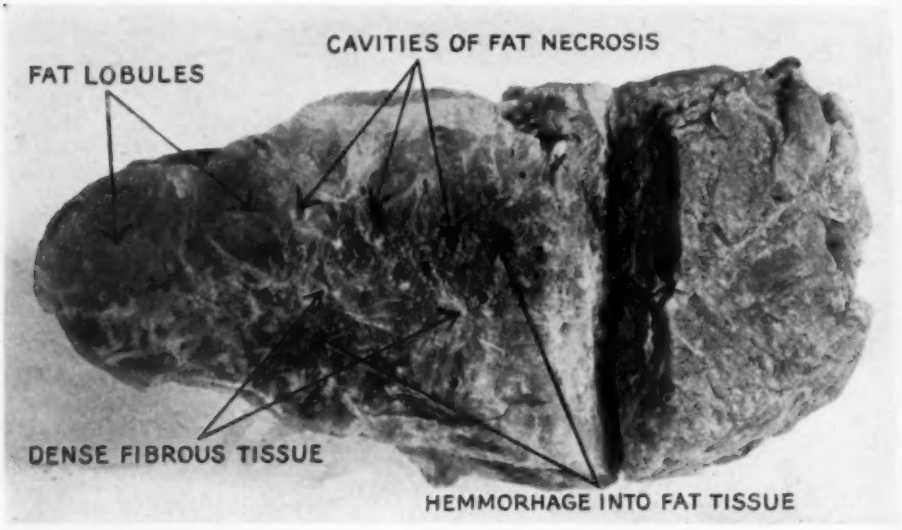

FIG. 7.—Case VI. Gross specimen four months after the injury. There is an extensive area of hemorrhagic products in the fat tissue. Numerous small cysts of fluid fat are scattered throughout.

Some years ago the patient had an abscess in the breast, which may account partially for the nipple retraction and elevation. There was an enlarged firm node in the left axilla.

Provisional Diagnosis.—Because of the tumor hardness, nipple elevation and retraction and the firm axillary node, we felt that we were dealing with a carcinoma of the breast, but the mass seemed so superficial that a definite diagnosis seemed impossible. X-ray examination of the lungs was negative for metastasis. A pre-operative cycle of X-ray treatments over the breast and drainage areas was given prior to operation.

Operation.—Under ether anæsthetic, a wide excision of the tumor was carefully made. Upon section the tumor was as hard as the average carcinoma, but contained two small cystic areas lying in dense fat tissue. (See Fig. 8.) Throughout the glandular tissue lying outside the tumor area were numerous small bluish cysts. We believed we were not dealing with carcinoma, but probably with a fat necrosis. The wound was completely closed save for a small split rubber tube drain.

Pathology.—Report by Dr. James Ewing. "The nodule shows chronic inflammation about a small area of liquefied fat. There is active growth of fat cells and fibroblasts with englobment of fluid fat. Formation of a few giant cells and infiltration of lymphocytes. There are a few minute cysts evidently containing fluid fat. There is no sign of carcinoma."

Post-operative Course.—The post-operative course of this case was entirely uneventful.

The following case report has been furnished us through the kindness of Dr. A. R. Kilgore, of San Francisco.

CASE X.—B. A., single, female of fifty-nine years. History was negative, except at

the age of forty-five years she had an artificial menopause following hysterectomy for fibroids.

Mammary History.—Four days before her admission to the hospital she accidentally noticed a small lump in the upper outer quadrant of the left breast. Since discovering the mass she had been conscious of a slight tingling or burning sensation.

Physical Examination.—Breasts were symmetrical, large, fatty but not pendulous. There was no nipple retraction. In the upper outer quadrant of the left breast, there was a pea-sized subcutaneous nodule which was very hard. This mass was freely movable in the subcutaneous tissue. Immediately beneath it and apparently within the breast tissue

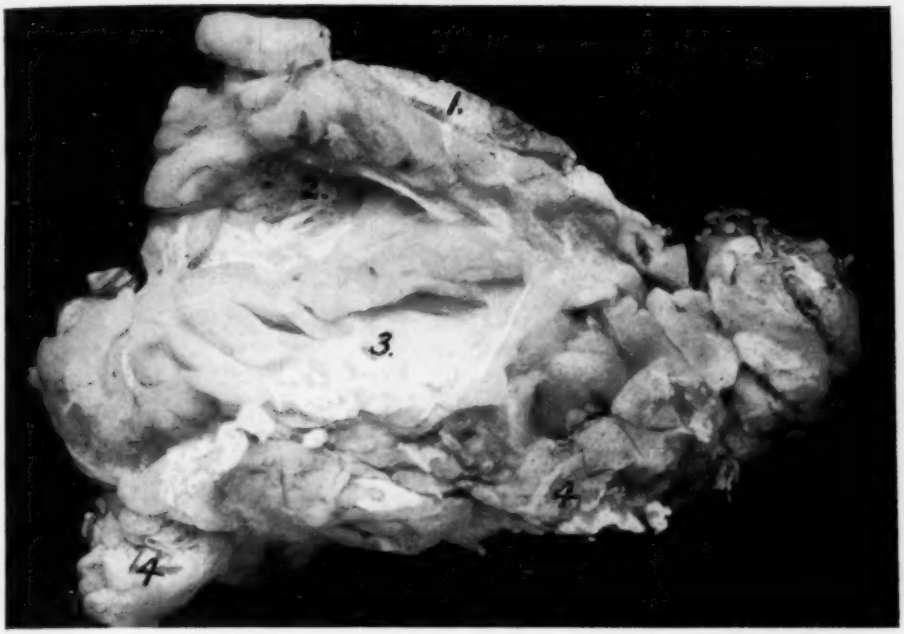

FIG. 8.—Case IX. Gross specimen. 1. Skin of breast. 2. Area of fat necrosis 1.5x1 cm. It is stony hard. There are a few cysts of fluid fat. 3. Fat lobules. 4. Breast tissue.

itself, was a lump the size of a lima bean, also freely movable. Upon pushing the breast toward the midline, a definite and well-marked skin retraction could be demonstrated. This was markedly limited to an area 1 cm. square over the nodule. No axillary nodes could be palpated.

Operation.—August 10, 1921. Novocain anæsthesia. The nodules were completely excised, together with a good zone of surrounding tissue. Cross-section of the specimen showed that the superficial nodule was composed of whiter fat than the normal yellow fat tissue surrounding it, the color resembling that of beef suet. The larger deeper nodule was not connected with the first. Upon section it had a similar appearance, except that it presented minute broken down areas, one of which was 2 mm. in diameter and contained degenerated material. This large second nodule seemed to be fat tissue, but of very much harder consistence than the surrounding normal fat. It was well circumscribed but not encapsulated.

Pathology.—Report by Dr. G. Y. Rusk. (Fig. 15.) "Microscopic examination of breast tissue shows a relatively large amount of fat and only occasionally traces of parenchyma. The few islands of breast tissue observed show a slight periductile infiltration with lymphocytes and occasional plasma cells. The main mass of tissue consists of fat with connective tissue septa. In the latter, one again finds evidence of old inflammatory reactions. The principal reaction occurs in the fat itself and consists of a marked

infiltration of the fat tissue with cellular fibrous tissue, mononuclear cells varying greatly in size, and larger ones having a pale, very finely reticulated cytoplasm suggesting developing fat cells, and other structures varying from cells with two or three nuclei, up to large nucleated syncytial masses. In going over the sections a single mitotic figure was observed. In a few places small slits are seen in the tissue, suggesting slight cholesterol deposit. The cytoplasm of the giant cells varies, sometimes appearing like that described in the mononuclear cells, and again being more eosinophilic and compact. The giant cells are distinctly of the foreign body type. Occasionally groups of eosinophiles are seen

FIG. 9.—Case V. Shows appearance of gross specimen eight years after the injury. The cyst was 2.5 cm. in diameter. The cyst wall was stony hard and seemed partially calcified. The cyst was filled with thick grumous material and small stones of calcification. The stones show well in this photograph.

among the smaller mononuclear cells and also a few polymorphonuclear neutrophiles, being apparently a more acute stage of the process.

"*Diagnosis.*—Reparative reaction following either infection or trauma in fat tissue."

Pathological report by Dr. James Ewing. "The sections show a chronic productive inflammation of fat tissue which is characteristic of the reaction of fat tissue to trauma. The fat in many cells is being absorbed by a proliferation of clear polyhedral cells within the fat cell membrane. This proliferation results in gradual replacement of the fat by the new cells. There is also considerable growth of new spindle fibroblasts, in the more advanced stages of the process. At several points there are small cysts, originally filled with fluid fat, about which many giant cells of various sizes are forming."

The following case report has been furnished us through the kindness of Dr. A. Hyman of New York City.

CASE XI.—A. M., married, German female, fifty-three years of age, was admitted to Mount Sinai Hospital on December 12, 1922. She had had three children and one miscarriage, and four years before admission a hysterectomy for complete uterine prolapse. Otherwise her past history was negative.

Mammary History.—There had been no previous history of abscesses of the breast, of caked breast or cracked nipples. Her chief complaint upon admission was the presence of a lump in the left breast. One month before admission, in attempting to close a window, it suddenly gave way and struck her in the left breast. The site of the injury was painful and a few days later the patient noticed a lump where the injury had been

received, over which the skin was ecchymotic. This mass in the breast had persisted up to the time of admission, but had not increased in size and had been painless.

Physical Examination.—The patient was a well nourished adult female of stocky frame. Approximate weight was 170 pounds. General examination was negative.

Breasts.—The breasts were large, pendulous and contained much adipose tissue. In the upper middle quadrant of the left breast about 6 cm. above the nipple, there was a small irregular hard mass, about 3 cm. in diameter. This mass was not tender, skin over it was not attached and the growth itself was fairly movable. There was an enlarged lymph-node which was not hard in the left axilla. Wassermann examination was negative.

Provisional Diagnosis.—A pre-operative diagnosis of a non-malignant breast tumor was made and the possibility of its being traumatic fat necrosis was noted on the chart.

FIG. 10.—Case III. Gross specimen ten years after hypodermoclysis. There are numerous cysts, the largest 2.5 cm. in diameter. Walls of the cyst are thick and hard. Cyst contents, sand sediment of calcification.

Operation.—December 9, 1922. Dr. A. Hyman. The tumor was excised through a small radial excision. Frozen sections showed areas of fat necrosis. The wound was immediately closed.

Pathology.—By Doctor Mandlebaum, of Mount Sinai Hospital. "Specimen consists of a mass of breast tissue, apparently fat, received in formalin. Microscopical examination shows adipose tissue with considerable increase in the amount of fibrillar connective tissue between the fat cells. In addition, there are numerous foci of lymphocytes present, which represent areas of inflammation of a chronic type, and many giant-cells of inflammatory character. (December 11, 1922.)"

Patient was again operated upon June 8, 1923. Pathological report by Doctor Mandlebaum.

"Specimen consists of adipose tissue received in formalin. The microscopical picture is quite similar to that noted in the former examination, excepting that the process is considerably more advanced. The interstitial connective tissue is quite dense and compact, the giant-cells are more numerous, and in addition, many fat cells are seen presenting the typical picture of necrosis. Some of these fat cells are filled with a granular detritus, while others show fine needle-like crystals. The diagnosis of fat necrosis can therefore be established. (June 8, 1923)."

The following case report has been furnished through the courtesy of Dr. A. A. Berg, of New York City.

CASE XII.—M. D., married, female, sixty years of age, was admitted to Mount Sinai Hospital early in March, 1923. She had had two children; her past history otherwise was negative.

Mammary History.—About three months before admission the patient suffered an injury to the right breast, followed by the development of a large hæmatoma. The hæmatoma finally disappeared after a period of several weeks. About six weeks after the disappearance of the hæmatoma, a swelling appeared in the right breast over the same area.

Physical Examination.—The patient was of moderate adiposity.

Breasts.—There was a tumor in the right breast, smooth on its surface, pure, tense but not fixed to the skin or pectoral muscle. No palpable axillary nodes.

Provisional Diagnosis.—A provisional diagnosis of traumatic cyst of the breast was made, and consent given for operation.

Operation.—March 14, 1923. Dr. A. A. Berg. The tumor was excised.

Pathology.—By Doctor Mandlebaum, of Mount Sinai Hospital.

"Microscopical examination of specimen removed from the breast of Mrs. D. shows small cysts containing red blood cells, fatty crystals and giant cells. (Phagocytes.) There is nothing present of malignant character. Diagnosis: Fat necrosis due to trauma."

The following two cases have been furnished us through the courtesy of Dr. Joseph C. Bloodgood, of Baltimore.

Case XIII.—M. B., married, female of about fifty-six years of age, was admitted to the hospital March 31, 1920, under the care of Dr. J. M. T. Finney. She had suffered cardiac palpitations for years. A hysterectomy had been done in 1917 for irregular uterine bleeding.

Mammary History.—Patient had had pain in both breasts for seven years, but the masses in the breasts had been noted but for two weeks.

Physical Examination.—Breasts were symmetrical and large. There were no palpable axillary nodes. There was a lump in the left breast in the upper outer quadrant 2.5 x 1.5 cm. The skin over it was slightly reddened with definite skin retraction and dimpling, was tender and was hard in consistency. There were two masses in the right breast, the first in the upper outer quadrant just beneath the skin, which was 1 cm. in diameter. The skin over it was slightly reddened. In the lower outer quadrant was a mass 3 cm. in diameter, the skin over it somewhat reddened. The mass itself was tender, irregular in outline and hard. Both masses showed skin retraction and dimpling.

Provisional Diagnosis.—Benign tumors of the breast. The following note by Doctor Finney is of interest. "This case was a most interesting one from a diagnostic standpoint. I have never seen anything quite like this condition. I was sure it was not malignant, although many of the characteristics of malignancy were present. It was simply a localized area of inflammation of fat in the breast. This inflammation involved the skin, producing retraction and dimpling, together with the pig-skinned appearance so often seen in connection with cancer."

Operation.—April 9, 1920. Doctor Finney. Exploratory incision. Excision of tumor from both breasts.

Pathology.—Report by Dr. Joseph C. Bloodgood. "Grossly the masses have not the appearance of cancer. From the left breast is an area of skin 7 x 4 cm. removed with a mass of fat. Just beneath the nipple you can see a little irregular non-encapsulated area, distinct from the surrounding fat, which palpates like cancer, but has no other gross markings of cancer.

"The area removed from the right breast is 1 cm. in diameter, irregular, no capsule, feels hard like cancer, but has not the appearance of cancer.

"Frozen section shows tumor composed of fat with a good deal of cellular fibrous tissue. No gland parenchyma. No histological evidence of cancer. There is a cellular granulation tissue in fat, numerous leucocytes, larger cells which might be called epithelial cells, which suggest to me plasma cells or endothelial lymph vessels. I even find here and there areas of fat necrosis. The tumor is apparently due to a chronic inflammatory reaction in the fat, with production of connective tissue and fibrous tissue."

Post-operative Course.—Patient well four years after operation.

CASE XIV.—L. M., White female, thirty-nine years of age, was admitted to St. Agnes' Hospital in June, 1923.

Mammary History.—Two weeks before admission, woman observed a tumor in the breast, outside the nipple zone. Patient had very large breasts which were very fatty.

Physical Examination.—By Dr. Joseph C. Bloodgood. "Inspection was negative. Breasts very large. Well developed nipple. No warts on nipples. No varicocele beneath nipples. Not the shotty breasts. As I pushed both breasts toward the sternum I saw three dimples in the nipple zone of the upper hemisphere, and right beneath this area I could palpate a mass that extended to the areola. It was superficial as if it were in

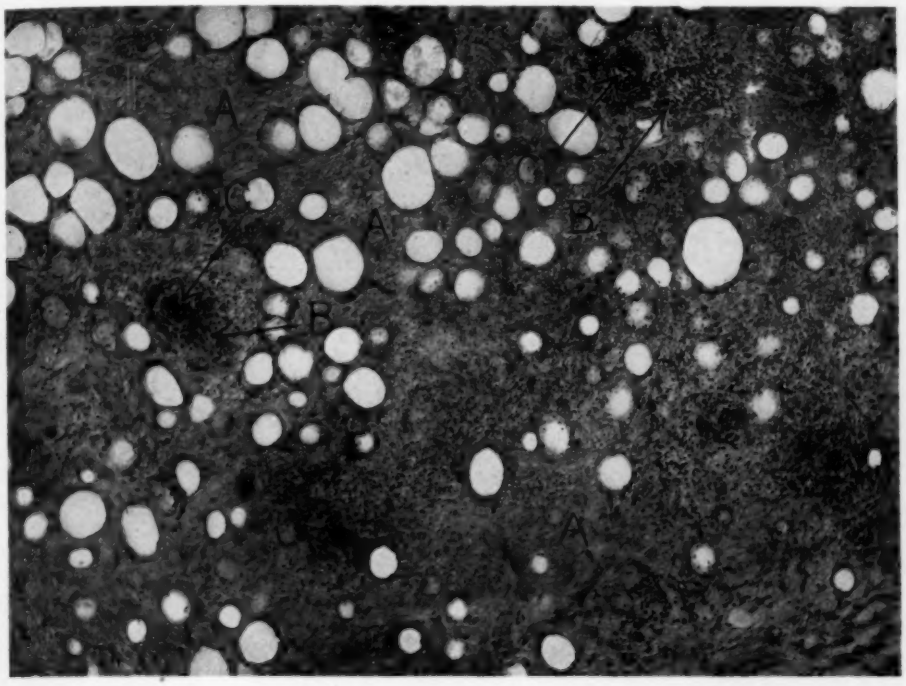

FIG. 11.—Photomicrograph. A. Necrosis. B. Lymphocytic infiltration. C. Obliterating endarteritis.

subcutaneous tissue. Felt like a bunch of worms. Leathery. It was irregular in outline. Nothing to be palpated in the axilla. Little tenderness."

Provisional Diagnosis.—"Breast benign tumor. Subcutaneous calcified and inflammatory lipoma. Tumor felt like dilatation of ducts outside of nipple area and was clinically malignant because of dimpling of skin."

Operation.—June 7, 1923. Doctor Bloodgood. Excision of area with dimpled skin, thinking it was dilated ducts. The mass was then bisected and diagnosed as calcified lipoma.

Pathology.—Report by Doctor Bloodgood. "On exploration, proved to be fat stroma with a number of subcutaneous areas but no calcification.

"*Microscopic.*—Section 2, subcutaneous fat, we have fat and in the fat irregular areas of lymphoid reaction apparently surrounding fat necrosis, perhaps the next stage to the necrosis would be the calcification. Beneath this are what we have originally diagnosed: dilatation of ducts, so the clinical diagnosis was part right and the gross diagnosis was part right. I did not see dilatation of ducts in the gross. Section 3, fat beneath, 2, largely breast with lymphoid areas and fat necrosis as in 2, and dilatation of ducts and lobules of breast. Section 4, fibrous tissue beneath skin, same fat, same lymphoid areas. Section 5, breast tissue and fat, same fat, same lymphoid areas fat necrosis. Here and there dilatation of ducts, fibrous tissue."

Life History.—A severe trauma to the breast produces a rupture of fat cells, and at the same time a rupture of small blood-vessels, with extravasation of blood into the tissues. If this hemorrhage occurs near the surface, ecchymosis may be apparent beneath the skin; however, if a hemorrhage occurs in deeper tissues, as in the hypodermoclysis cases, no ecchymosis may be observed. Necrosis of the fat tissue appears soon after the injury, and giant cells have been found in the tumors at the end of five weeks. An obliterating endarteritis may appear a few months after the injury. See Case I,

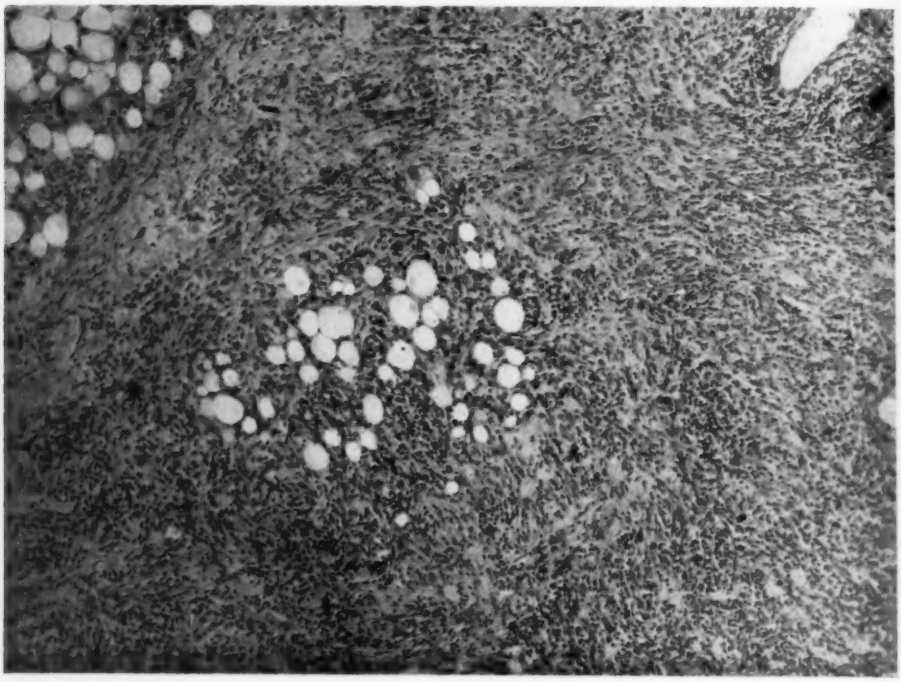

FIG. 12.—Case I. Photomicrograph showing about fat cells, an inflammatory infiltration with a marked productive reaction of the fibrous tissue.

showing marked changes of this character three months after receipt of the trauma. (Fig. 11.) In no early case was there an oil cyst of any large size. Several years after the beginning of the process, as seen in Cases III and V (Figs. 9 and 10), definite large cysts 2.5 cm. in diameter, with a thick laminated fibrous wall, may be expected. (Fig. 14.) Therefore, multiple cysts of small size are usually seen early, but a small number of larger cysts are to be expected later in the course of the disease. After several years these cystic cavities may contain a mixture of small and large calcareous masses, sometimes as fine as sand, other times as large as 5 mm. in diameter, mixed with a thick, brownish, sticky detritus. Had these tumors been left undisturbed, it seems possible that the entire cyst contents and cyst wall would have become a solid calcareous mass.

Incidence.—Our former study gave an incidence of traumatic fat necrosis of the breast in comparison with primary carcinoma of the breast of 1.8 per

cent. The additional cases occurring in the clinic have now raised this percentage figure to 2.5 per cent. Our own experience with this disease, coupled with the reports of other observers, proves that it is not uncommonly encountered in dealing with tumors of the mammary gland.

Age.—The youngest patient of the twenty under report was thirty years of age, the oldest sixty-three. Therefore, the lesion is encountered in the so-called cancer decades and most often in mid-life. The reason for its occur-

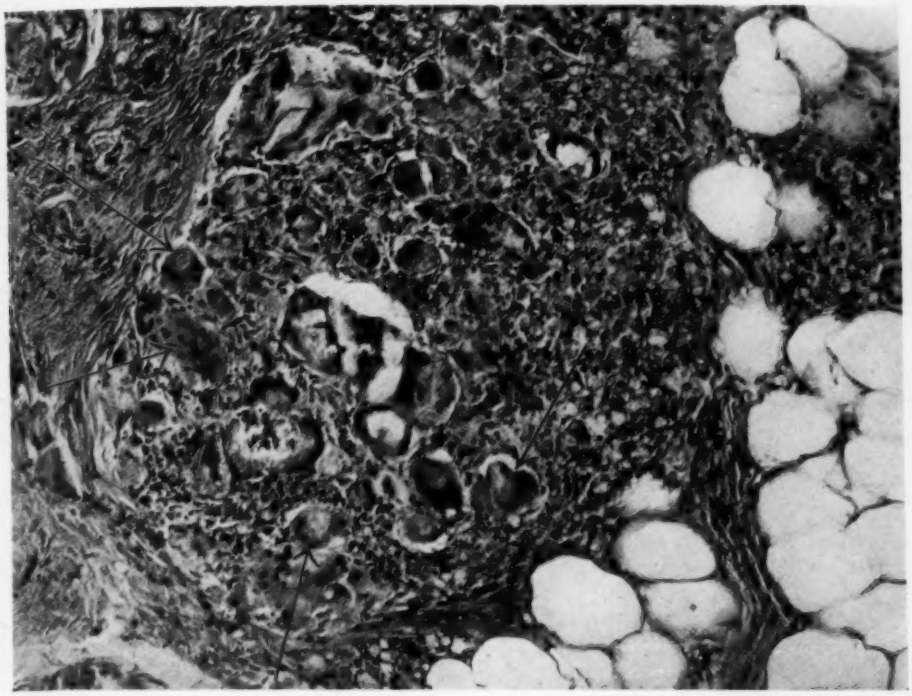

FIG. 13.—Case VI. Photomicrograph showing nests of large and small giant cells.

rence in mid-life is probably due to the fact that in youth and old age an excess of fat deposit in the breast is much more rare.

Weight.—In practically every incidence the patient was far beyond the normal weight. The importance of this factor is illustrated by the following table:

Weight Chart

1	Case	211 pounds
3	Cases	190 to 200 pounds
3	Cases	180 to 190 pounds
1	Case	170 to 180 pounds
1	Case	160 to 170 pounds
3	Cases (short in stature)	150 to 160 pounds

In the cases in which it was recorded the average weight was 176 pounds.

Type of Breast.—Nineteen of the twenty cases had definitely obese breasts. As the disease occurs in unusually adipose individuals, one would expect to

encounter in such patients abnormally fat breasts. The breasts vary in type from those which are large and pendulous (Figs. 1, 2 and 3), reaching almost to the umbilicus, to those which are protruding and massive. (Figs. 4 and 5.) Such breasts are more readily subject to trauma and contain far more fat tissue than the average mammary gland.

Trauma.—The degree of trauma is usually severe. In one instance the

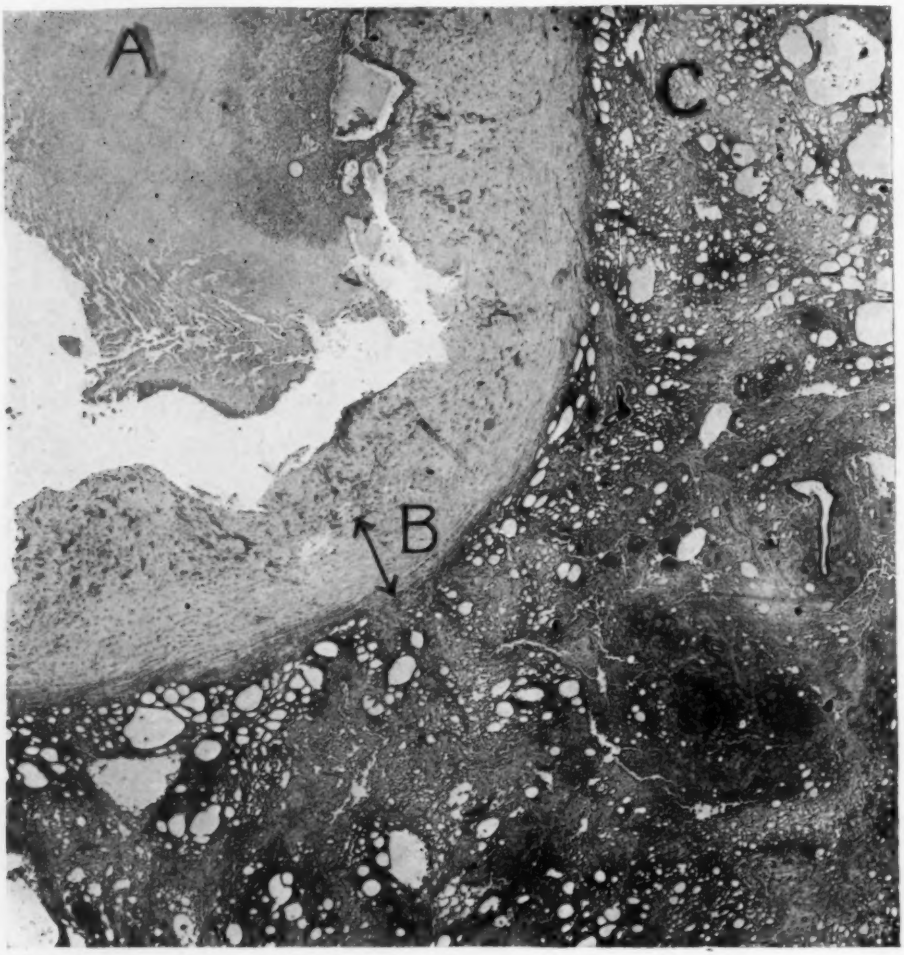

FIG. 14.—Case III. Photomicrograph of portion of 2.5 cm. cyst. A. Represents the fatty necrotic material which fills the cyst. B. Represents the cyst walls showing the laminated connective tissue structures. C. The outlying necrosis in that tissue.

patient fell downstairs with a picture frame under her arm, the corner of the frame striking the breast. Another patient fell thirteen steps, a trauma being inflicted upon the breast by the sharp corner of a pedestal at the bottom of the stairs. A third patient was struck violently in the breast by the point of an elbow. These instances illustrate the production of the lesion by a mechanical injury of marked degree. In three of the patients the trauma was furnished by a preceding hypodermoclysis, and we feel that a tumor

developing in the breast following hypodermoclysis, is more likely to be due to fat necrosis than to any other type of lesion. However, in four of the cases in our series no definite history of trauma could be elicited, while in two other instances no statement was made as to presence or absence of trauma. In fourteen of the cases, or 70 per cent., the traumatic history was definite. As we have pointed out in a former contribution, the surgeon should assure himself that the site of trauma is identical with the location of the tumor.

Absence of Pain.—Traumatic fat necrosis of the breast is characterized by its painlessness. In but three instances was there any complaint of definite pain. However, there is a certain amount of tenderness in and about the breast following the receipt of the injury, but this symptom generally disappears in a short time.

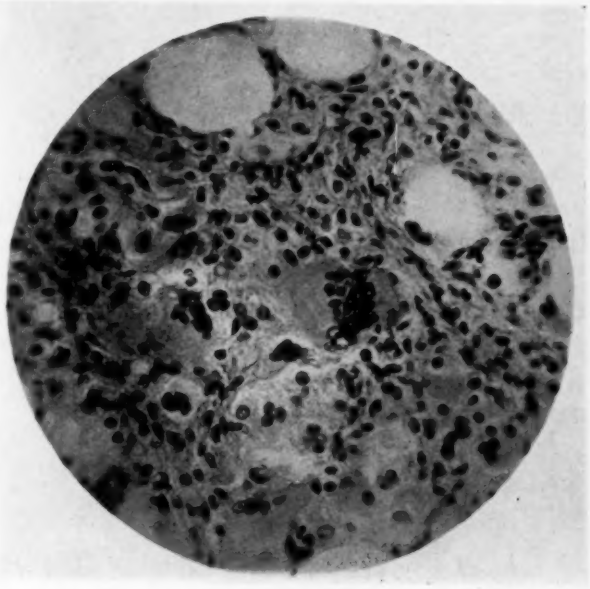

FIG. 15.—Case X. Photomicrograph showing large and small giant cells.

Hardness.—This important symptom was present in fifteen of the twenty cases, and the stony hardness of fat necrosis is largely responsible for the difficulty of clinically distinguishing the lesion from carcinoma. One of the cases under report, Case XII, was elastic in consistency, while Case XIV was described as of "leathery" feel.

Fixation to the Skin.—Skin adherence was present in fourteen cases, or 70 per cent. of the total number. The appearance presented by the skin attachment over the tumor may be identical with that seen in cases of mammary carcinoma, as is illustrated by Fig. 6, in which the appearance of the tumor followed a hypodermoclysis.

Nipple Retraction.—This sign is rarely present, occurring in but four of the cases, or but 20 per cent. In a tumor of long standing the absence of nipple retraction is of considerable importance in a differentiation from carcinoma, in which disease it is quite uniformly to be expected.

Attachment to Deeper Parts.—It seems probable that this sign is produced by the inflammatory reaction and subsequent fibrosis following a hemorrhage deep in the breast with the formation of adhesions to the pectoral fascia. This symptom was elicited but four times in the entire series, or but 20 per cent. It must be regarded a fairly inconstant symptom.

Axillary Nodes.—In the palpation of any axilla, and especially in the axilla of a fat woman, it may be impossible by the most painstaking examination to make out the presence or absence of lymph-nodes, or to determine their size and consistency. In no instance of the cases in this series were any nodes of hard consistence palpated prior to operation. In five instances small soft nodes were to be felt, but in the remaining fifteen cases palpation of the axilla was negative.

Size of the Tumor.—The tumor varied in size from a small nodule 1 cm. in diameter to a mass 6 x 8 cm. Therefore, the nodule of fat necrosis following trauma of the breast shows no constancy as to size. A nodule of a few centimetres in diameter is to be expected. We have never seen a large tumor produced by this lesion.

Period of Development following the Trauma.—Of the fourteen cases in whom a definite history of trauma was obtained, but one gave a history of an immediate appearance of the tumor following the trauma. In Case XI a tumor was recognized a few days after the injury, while in Case IV a month had elapsed following the receipt of the trauma. Upon the other hand, in Cases III and V there was a period of ten years and eight years, respectively, from the time of injury to the appearance of the mass in the breast. Therefore, no rule can be laid down as to the period of time between trauma and the recognition of the tumor.

Ecchymosis.—In eighteen cases a statement was made as to the presence or absence of ecchymosis, and in nine instances, or 50 per cent., the findings were positive. It is possible that in some instances a transient ecchymosis might have been unobserved by the patient.

Graphic Chart of Symptoms and Diagnosis

19 cases showed .....fatty breast
15 cases showed .....stony harness
15 cases were .....painless
14 cases gave history of .....severe trauma
14 cases showed .....skin fixation
13 cases were diagnosed .....non-malignant
9 cases gave history of .....ecchymosis
7 cases were diagnosed .....cancer
5 cases had .....soft axillary nodes
4 cases showed .....nipple retraction
4 cases showed .....deep attachment

TABLE I.

Summary of Cases.

Authors		Age	Weight lbs.	Trauma	Pain	Tumor hardness	Obese	Nipple retraction	Skin fixation	Deep attachment	Axillary nodes	Ecchymosis	Duration	Pre-operative diagnosis
Case I.	Lee and Adair	52	190	+	O	+	+	O	+	+	O	O	3 mo.	Ca.
Case II.		36	211	+	O	+	+	O	+	O	+	O	7 mo.	Ca.
Case III.		40	191	+	O	+	+	O	O	+	O	O	1 mo.	Non. Mal.
Case IV.		47	152	+	+	+	+	+	+	O	O	+	10 mo.	Non. Mal.
Case V.		54	180	+	O	+	+	O	+?	O	O	+	3 wks.	Non. Mal.
Case VI.		48	196	+	O	+	+	O	+	O	+	+	5 mo.	Non. Mal.
Case VII.		44	181	O	O	+	+	+	O	O	O	O	2 wks.	Mal.
Case VIII.		30	160	O	+	+	+	O	O	O	O	O	3 mo.	Non. Mal.
Case IX.		45	186	O	O	+	+	+	+	O	+	O	4 wks.	Non. Mal.
Case X.	Kilgore	59		O	O		+		+	O	O	O	4 days	Non. Mal.
Case XI.	Hyman	53	170	+	O	+	+		O	O	+	+	1 mo.	Non. Mal.
Case XII.	Berg	60		+			+		O	O	O	+	3 mo.	Non. Mal.
Case XIII.	Bloodgood	56			+	+		+	+		O		2 wks.	Non. Mal.
Case XIV.	Bloodgood	39					+				O			Non. Mal.
Case XV.	Parsons	42	150?	+?	O		+	O	+			+	5 days	Non. Mal.
Case XVI.	Cohen	35	150	+	O	+	+	O	+	O	+	O	4 wks.	Non. Mal.
Case XVII.	Lanz	36		+	O	O	+	O	+	O	O	O	3 wks.	Mal.
Case XVIII.	Kuttner	63		+	O	+	+	O	+	+	O	+	6 wks.	Mal.
Case XIX.	Berner	34		+	O	+	+	O	+	?	O	+		Mal.
Case XX.	Stulz and Fontaine	53		+	O	+	+	O	+	+	O	+	1 mo.	Mal.
				14	3	15	19	4	14	4	5	9		

Diagnosis.—The clinical diagnosis of traumatic fat necrosis of the breast is often difficult, but in certain cases a correct diagnosis can be rendered before operation. The most important factors in the diagnosis of this condition are:

1. It always occurs in a fat breast.
2. It usually occurs in a corpulent subject.
3. A definite history of severe trauma can usually be obtained.
4. The tumor is painless.
5. In the vast majority of cases the consistency of the tumor is one of stony hardness.
6. Skin adherence is present in a large number of cases.

The differentiation from carcinoma is at times difficult. In those patients in whom the lesion has existed for several years carcinoma may readily be excluded. In more recent cases, extending over months or years, it may be impossible to distinguish the two conditions. Of the twenty cases, a diagnosis of non-malignancy was rendered before operation thirteen times. In seven instances a pre-operative diagnosis of carcinoma was made. The diagnosis of malignancy was therefore incorrectly rendered in 35 per cent. of the cases.

Treatment.—A non-traumatizing excision of the tumor, together with a reasonably wide zone of surrounding tissue, will yield a satisfactory result. It seems wise to emphasize the necessity of a non-traumatizing operation, for in a fat breast, injury to the adipose tissue may reproduce the lesion. We have seen one instance of traumatic fat tissue appearing in a scar following an excision of a benign tumor. In cases of long standing, if the surgeon feels fairly certain that he has correctly diagnosed the condition, no excision or treatment of any sort need be strongly urged. Especially is such an attitude justified if the patient is a little worried because of the tumor in the breast. In general, however, we feel that the wisest course is excision.

CONCLUSIONS

1. Traumatic fat necrosis of the female breast is a definite clinical disease.
2. Its importance lies mainly in its striking similarity to carcinoma of the breast, not only as to its clinical appearance, but also as to its gross and microscopical picture.
3. A correct diagnosis of the condition prior to operation can sometimes be made.
4. Surgeons should recognize this lesion and constantly be on the lookout for it.

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THE NEUROTIC OR IRRITABLE ABDOMEN*

By Leonard Freeman, M.D.
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A neurotic or irritable abdomen may be defined as one in which disturbances of the sympathetic nervous system cause undue irritability of the muscles of the gastro-intestinal tract, and often those of the abdominal wall, perhaps combined with cutaneous hyperæsthesia and exaggerated pain and tenderness. The condition sometimes arises from hysteria or from central lesions, but usually is due to pathology within the abdomen itself. With these local manifestations, and depending upon them, is frequently associated a general nervous irritability, manifesting itself in neuroses of various kinds.

Surgeons are familiar with these "irritable abdomens." Such patients are difficult to examine, owing to hypersensitiveness and undue contractility of the muscles. They are subject to spasm of the pylorus and to disturbances of the vascular system, the functions of the stomach, the liver, the intestines and other organs. When the abdomen is opened the bowel frequently is found to be so sensitive that it contracts spasmodically at the slightest touch. Owing to this "keyed up" condition, such patients easily become introspective, dwelling unduly upon their internal sensations, some even acquiring consciousness of their normal peristaltic activities—in other words, they develop into so-called neurasthenics.

In order to arrive at an understanding of the question under discussion, one must bear in mind that although the cranio-spinal and sympathetic nervous systems are quite distinct and have different functions, nevertheless they are intimately united in divers places, so that the activities of the one are readily communicated to the other. For instance, the spinal ganglia receive many visceral sympathetic fibres and also send fibres to the vegetative system, which, in turn furnishes numerous connections between the various spinal ganglia. It is important to note that the visceral connections do not seem always to take place with regularity, sometimes occurring with the ganglion above or with the one below, instead of with the one to be expected. One also should remember the bewildering intricacy of the abdominal sympathetic system, with its numerous ganglia and plexuses and their multitudinous connections. The whole jumble may be compared with the telephone-system of a large city, with its maze of wires to individual residences and its various intercommunicating local stations.

When the terminal sympathetic filaments in the mucous and muscular coats of the bowel (plexuses of Meissner and Auerbach) are stimulated *normally* by the passage of food, the proper ganglia are communicated with and peristalsis occurs. Connection is also established with the pylorus, with other involuntary muscles, and with numerous secretory glands and organs,

* Read before the Chicago Medical Society, April 22, 1924.

thus regulating the complicated process of digestion. But if the stimulation is *pathologically* increased, these activities are exaggerated or otherwise disturbed; and, in addition, impulses may overflow to the spinal ganglia and through them to the corresponding cranio-spinal nerves, causing rigidity and tenderness of the abdominal walls. And, conversely, when over-stimulation of the central nervous system exists, as in great emotional excitement, derangement of the internal functions may result; in fact, a kind of "vicious circle" arises between the vegetative and somatic systems, in which an irritation of one reacts backwards and forwards, with augmenting intensity, between both of them.

When abdominal pain, rigidity and tenderness appear, they usually are found in certain areas corresponding to the normal nerve connections. Sometimes, however, as mentioned above, these connections are abnormal, so that instead of the proper spinal nerve receiving the stimulus, it may be the one above or the one below, thus causing confusion in the location of the internal trouble and possibly a mistake in diagnosis. In cholecystitis, for example, the tenderness and rigidity may be referred to the appendix, and in appendicitis, to the gall-bladder.

The existence of sensory sympathetic neurons is commonly recognized—afferent fibres carrying sensations of various kinds to the central nervous system—and it is known that abdominal colics depend upon these fibres; but the prominent part actually played by the sympathetic nerves in the transmission of pain is not so generally realized. As illustrations of this may be mentioned—pectoral and abdominal angina, various abdominal crises, and the pain connected with acute pancreatitis, the passage of biliary calculi, certain forms of gangrene of the extremities, ileus, spasm of the pylorus, gastric ulcer, etc.

Some recent observations have emphasized the intensity and stubbornness of such pain. For example, Salomon and Schwartz † report an instance of pre-senile gangrene of the toes accompanied by intense suffering, in which a femoral peri-arterial sympathectomy was performed under spinal anæsthesia. In spite of the absence of ordinary sensation, when the sympathetic plexus was pinched with forceps intense pain was felt in the neighborhood of the gangrenous area. A similar stubbornness also characterizes contractions of the unstriped muscles, as seen in spasm of the pylorus or intestine, which often persists during operation in spite of the most profound general anæsthesia.

An important fact to note in connection with irritable abdomen is that the sensitiveness of the sympathetic neurones is exaggerated unduly by most pathologic lesions, such as chronic appendicitis, gastric ulcer and cholecystitis, just as it is similarly increased in gangrene of the extremities.

In the light of what has been said, it may reasonably be concluded that the neurotic abdomen, with its many bizarre manifestations, both local and general, is dependent upon an abnormal activity of the sympathetic nervous

† Bull. et Mem. de la Soc. de Chir. de Paris, Nov. 20, 1923, p. 1310.

system, with its infinite ramifications and inter-communications, both with itself and with the cranio-spinal system.

While it is true that the physiologic and pathologic phenomena of the sympathetic nervous system still remain largely in obscurity, nevertheless we are beginning to accumulate enough illuminating observations to justify a certain amount of theorizing. Quite recently we have learned much regarding the curious effects of sympathectomy in a multitude of conditions, such as angina pectoris, bronchial asthma, exophthalmic goitre, causalgia, trifacial neuralgia, gangrene, Raynaud's disease, epilepsy, ulcer of the stomach, spasm of the pylorus, and various secretory abnormalities.

I now wish to call attention to several specific forms of irritable abdomen, of which the significance, perhaps, is not quite as generally understood as it should be.

Irritable Abdomen from Chronic Obliterating Appendicitis.—It often has been said that there is no such thing as chronic appendicitis; that what is known by this name really is a recurrent appendicitis—recurrent attacks alternating with free intervals. What we find in the intervals is merely the result of the periods of inflammation and not the inflammation itself.

There is, however, a true chronic appendicitis, which is not uncommon. It is represented by the familiar "obliterating appendicitis," a condition in which the inflamed mucosa gradually disappears, as in atrophic rhinitis, converting the organ into a cicatricial cord with only a minute lumen or even no lumen at all.

Obliterating appendicitis is a slow process, often extending over many years. It begins at the tip and progresses toward the base, with a sharp line of demarcation between the proximal diseased mucosa and the distal portion which already has become atrophic. There are seldom any acute attacks. It is an ever-present, ever-progressive, truly chronic inflammation.

Such an appendix often is associated with an irritable abdomen, characterized by spasm of the pylorus, hyperacidity, a tendency to intestinal colics, flatulence, biliary stasis, spasticity and hypersensitiveness of the abdominal walls, and general nervous instability.

Even after the chronic inflammation has spent itself, converting the appendix into a fibrous cord, the general and local symptoms often continue until an appendectomy is done. This has never been quite satisfactorily elucidated, although it might reasonably be supposed to be connected with the sympathetic fibres, which exist normally in the appendix in even greater numbers than in the intestine. In fact, many surgeons consider it so improbable that such a mere cicatricial string can be harmful that they fail to regard it seriously, and may even refuse to remove it. Its importance, however, is sufficiently recognized by others, although a proper dramatic effect is sometimes lacking at the exhibition of so insignificant an operative trophy.

Recently my attention has been called to the observations of Schweizer,

Masson,‡ and others, who frequently have detected the presence of neuromata and other abnormal conditions of the sympathetic fibres in obliterated appendices, the fibres being greatly increased both in size and number ("appendicite neurogene"). It would seem reasonable to assume that the development of an irritable abdomen in such cases can be explained by the pressure of contracting fibrous tissue upon these pathologically altered nerves, which frequently have been "amputated" by ulceration, just as occurs with the somatic nerves in sensitive scars and amputation stumps. Hence the importance of cutting such appendices completely out of the cæcum instead of leaving a proximal end, as is often done. A similar explanation may also apply to other conditions associated with much fibrous tissue, such as chronic ulcers of the stomach. Masson even ventures to apply his hypothesis of nerve irritation to the entire intestinal tract, where the submucous plexus is sometimes subjected to conditions similar to those arising in the appendix, which, if true, would go far towards explaining many obscure phenomena.

Irritable Abdomen from Enlargement of the Mesenteric Lymph-nodes.—This disease, although quite common in children and young adults, is not recognized frequently by surgeons. It manifests itself by the presence of numerous small, soft lymph-nodes, seldom larger than a pea. They can be felt as smooth nodules, and seem as small reddish spots, scattered profusely through the mesentery. There is no alteration in the peritoneum, although there is frequently considerable clear fluid in its cavity. When we bear in mind that these nodes are surrounded by an intricate maze of sympathetic fibres, connecting with numerous plexuses and ganglia throughout the abdomen, it is not surprising that mesenteric lymphadenitis can give rise not only to muscular and other disturbances of the intestine itself, but also engender various reflex phenomena in quite distant parts, such as the pylorus and the abdominal wall.

The infecting agent probably enters through the more or less intact intestinal mucosa. Influenza seems to play a prominent part in the etiology, although other causes also exist, including tuberculosis, as I have frequently demonstrated by the inoculation of guinea-pigs.

The symptoms are typically those of an irritable abdomen, and often so suggestive of appendicitis that a differential diagnosis becomes uncertain. They consist of:—(1) Abdominal pain, tenderness and rigidity, which are moderate and diffuse, but with a predilection for the right, lower quadrant, due, perhaps, to the fact that the peripheral attachment of the mesentery runs in that direction. (2) Transient colics, from spasm of the intestine (during laparotomies it is interesting to observe how the bowel undergoes violent spastic contracture almost at a touch, like a sensitive-plant). (3) Various gastro-intestinal disturbances including pyloric spasm. (4) Loss of energy and flesh and a moderate rise in temperature together with nervous irritability.

‡ P. Masson, *Annales D'Anatomie Pathologique*, vol. i, No. 1, p. 3. "Appendicite Neurogene at carcinoides."

Irritable Abdomen from "Intestinal Grippe."—This occasionally occurs as a post-operative complication when an abdominal operation chances to coincide with an attack of influenza. The consequences may be both perplexing and serious.

Following the operation, the patient complains of unusually severe pain around the centre of the abdomen. At first this is attributed to flatus, but sooner or later it becomes evident that the patient is seriously ill. The constant pain increases until it becomes almost unbearable, and is accompanied by a rise in temperature and pulse. The abdomen distends and obstipation develops, although it is possible, for a time at least, to obtain inadequate results with enemas and pituitrin. Vomiting is not a prominent feature, but there may be gastric dilatation.

At first nothing can be detected in the lungs, but if the patient lives long enough pneumonia appears, with characteristic cough and bloody expectoration. Involvement of the sensorium is common, beginning with restlessness and insomnia and terminating in delirium and coma. The mortality is very high, death usually resulting in from twenty-four hours to a week.

It will be noted that the outstanding features of the trouble are severe abdominal pain, distention and obstipation. The supervention of these things upon an operation renders the diagnosis puzzling, and the anxious surgeon easily may be led into a useless operation for a supposed organic obstruction, a perforation, an appendicitis, a cholecystitis, or a peritonitis.

Although I believed this definite, clearly defined post-operative complication was due to "intestinal grippe," I failed to grasp the reason for its peculiar manifestations, especially the intense and constant pain. The explanation has recently been given, however, by Colmer,§ who cites three cases of grippe with such violent abdominal symptoms that laparotomies were done under the impression that organic intestinal obstruction existed. In each instance nothing was found but a marked spastic contracture of the jejunum, with dilatation of the remainder of the digestive tract. This seems to be a satisfactory explanation of the pain, having the advantage of not being a mere theory, but of being supported by operative findings.

Colmer suggests that this spastic ileus may be due to either disturbance of the central nervous system or to the irritation of sympathetic nerves by the enlargement of the mesenteric glands. I am strongly inclined towards the latter view, because I so often have seen local intestinal spasm in the presence of mesenteric lymphadenitis; and, furthermore, if the trouble had its origin in the central nervous system one would expect to find spasm of much greater length of bowel than is actually found. If Colmer's view is accepted, there would be excellent reason for the therapeutic use of antispasmodics, such as atropin, as has been done successfully in a number of reported cases.

§ "Ueber spastischen Ileus bei Grippe." Zentralblatt fur Chirurgie, Dec. 30, 1922, p. 1931.

STUDIES IN BILIARY TRACT SURGERY*

A SURVEY OF 130 CONSECUTIVE SURGICAL CASES

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A RECENT writer [1] has said, speaking broadly, "cholecystitis is a disease which begins in youth, but is first recognized and properly treated in old age. The importance of this subject in old age will be noted when it is remembered that every tenth old woman coming to autopsy shows gall-stones, while there are many more disclosing cholecystitis without stones."

These thoughts fit very clearly with a study made of 130 consecutive cases operated on for gall-bladder disease by various surgeons at the Methodist Hospital, Philadelphia. There was no selection of cases and the operations were not the work of any one surgeon, but were the consecutive cases operated on by all the members of the staff and the extra-mural surgeons as well. This is a series such as would occur in any of our hospitals of a similar character.

The series averaged 44 years in age, ranging from 15 to 76 years. The majority of stones and empyema cases were over 55 years, 110 were women and 20 were men. One hundred and thirteen were married and 17 were single. The average duration of symptoms was two and a half years, the range being from one week to fifteen years.

Pain was a universal and common symptom. In some it was continuous, in others intermittent. It was typical, with radiation from the right epigastrium to the right scapular region in 58 cases. It was restricted to the right epigastrium in 37 cases. A tender liver edge was the most prominent sign. In 17 cases the pain was described as boring in character and limited to the back. Ten cases of definite typical colic were described.

In 75 per cent. of the cases belching was a very prominent and early symptom and was associated very often with nausea, prostrating headache, and general weakness, which the patient usually termed "biliousness."

Constipation was noted with marked frequency, while diarrhœa was charted in 7 cases. Jaundice was noted at some time or other in 25 cases. Clay-colored stools were mentioned in 8 histories.

In the past medical histories—typhoid fever was mentioned in 10 cases, occurring from 6 to 40 years previous. Tonsillitis and sinusitis were charted in 25 cases. Appendicitis and intestinal disturbances were mentioned in 70 cases. Appendectomy had been performed upon 6 of the cases at some previous operation. Thirteen gave history of previous pelvic disturbance or operative interference for those structures. Nephropexy had been done previously in several women. Several cases showed right-sided pyelitis.

*Read before the Philadelphia Academy of Surgery, May 5, 1924.

The constitional signs were: fever with chills, which usually subsided a few days after admission, except in deep phlegmonous and long standing stone cases.

The prominent physical finding in the quiescent stages was right upper abdominal tenderness, especially along the liver edge.

A definite mass or palpable gall-bladder was noted in only 7 cases.

Three cases showed lower abdominal signs, while definite note of "no tenderness" was made in a considerable number. Some of these latter showed marked stone formation at operation. In a number of cases, the myocardium was of poor character, not an unexpected finding in a series of persons, many of whom were past middle life, and showing hypertension and menopausal disturbances.

The Röntgen-ray examination was seldom more than suspicious or suggestive. Fairly definitely outlined and distended gall-bladders were reported in 15 cases. Possible stone presence was made in 12 cases. A definite report of stones was made in 4 cases only. The findings at operation, as a whole, far surpassed these conservative reports.

Bile was studied in a considerable portion of the cases. Results were bacteriologically negative in a large percentage of cases. Streptococcus (unidentified) was reported 6 times. Staphylococcus aureus was found in 2 cases, staphylococcus albus was found in 5 cases. Bacillus coli was found in 5 cases, in 1 of these bacillus coli infection of the right kidney was associated.

Many cases of gall-bladder disease probably originate early in life, and persist with no, or only vague symptoms. Diseased conditions of the gall-bladder or biliary tract may be divided into those in which gall-stones do not occur and those in which the occurrence of calculi in some part of the biliary system overshadows, by its presence, those other elements which may have a more important bearing than the stones themselves.

At surgical intervention,[3] the condition of the gall-bladders themselves can be approximately summarized in 3 forms: (1) Gall-bladders of normal size and shape, with dark viscid bile, usually sterile; (2) dilated gall-bladders, showing a normal or only slightly abnormal structure, with usually an impacted stone in the neck or in the cystic duct; (3) large distended gall-bladders, the walls of which show moderate or marked grades of atrophy, especially of the mucous membrane and the muscularis.

There are often a various number (from one to several hundred) of various sized stones, which lie loose in a large or small amount of thin bile. Gall-bladders, containing stones, and in which infection has taken place, usually contain a thin pus or more rarely a thick creamy pus. The walls of the gall-bladders will often be found thickened and œdematous.

It is therefore apparent from studies of this sort that the various pathological pictures are highly individual. The various conditions found are but stages or progressive steps from simpler processes.

Of especial interest are the changes noted in the liver in some newer studies. In chronic cholecystitis, the liver often presents a picture practically

identical with that of an early cirrhosis. The inflammation appears to be principally a pericholangitis. The stones which come from and are at times packed in the intra-hepatic ducts, intra-hepatic cholelithiasis, a persisting or recurrent cholelithiasis, are most probably due to a persisting bacterial infection of the ducts or liver parenchyma.

The operative findings were as follows:

A definite thickening or disease of the walls of the gall-bladder, marked adhesions, with attachment to and thickening of neighboring viscera and stones in the biliary tract were found in 70 per cent. of the cases. Enlarged glands around the cystic duct area, thickening of the liver capsule and parenchyma were described many times in the operative notes. Gangrenous or phlegmonous cholecystitis was found in 12 cases.

Induration of the head of the pancreas was noted in 5 cases only. In 75 cases cholecystectomy was performed. In 41 cases drainage was instituted. Choledochostomy was done 6 times. Halstead's procedure (drainage of the common duct through the stump of the cystic duct) was done once. There were no cases reported of cholecyst-gastrostomy or cholecyst-duodenostomy.

In this series, appendectomy was performed 28 times.

It will be of interest to compare the degree and character of the pathology and complications in the cholecystectomy and the drainage series.

Extensive adhesions were encountered in 30 cases of cholecystectomy, while 25 of similar character were found in the much smaller drainage lot. There were 28 stone cases in the cholecystectomies and 14 in the drainage series. Four cases of phlegmonous cholecystitis were found in the cholecystectomies and 8 in the drainage cases.

There were 11 secondary cases, 9 being secondary to drainage procedures, and 2 followed cholecystectomies. The 9 drainage cases had been performed 1 to 10 years previously. The period of relief from the original symptoms ranged from "no relief" whatever in the earliest secondary (re-operated after 6 months) to 9 years. A great increase in adhesions to the surrounding structures was noted uniformly. The gall-bladder walls were thickened. Stones in the gall-bladder imbedded in the walls or blocking the cystic duct were noted in 4 cases of the 11.

Cholecystectomy was done routinely upon this group, except in 1 case. In 1 of the secondary cases, after cholecystectomy, return of symptoms had been present for 1 year (the operation had been done 5 years previously), and the adhesions were very extensive, involving the liver, intestines and biliary ducts. Choledochostomy was performed on this patient.

Another case in the cholecystectomy series, operated on 5 years before, showed pain, jaundice, and vomiting for 2 weeks before the secondary operation, and a report from the patient as having had "poor health" for 6 months before this. Upon opening the abdomen, a biliary cyst was found and drained. The common duct was obstructed by dense adhesions. This patient came to a third operation and the result will be given in the follow-up digest.

The complications met in the cholecystectomy series include a case of perforation of the colon and the duodenum by a very large stone. The upper gall-bladder communicated with the colon, the lower gall-bladder with the duodenum.

Internal hemorrhage from slipping of a ligature necessitated reopening in 1 case, while development of hepatic abscess caused rib resection for drainage in another case. Two cases of malignancy were encountered, 1 of the gall-bladder, the other of the liver encroaching upon the gall-bladder tract.

Literature on abdominal adhesions has been scanty, contradictory and inadequate. The majority of recent writers have considered adhesions from a surgical point of view, usually as the basis of personal opinion, rather than published facts. In such vein, Morris[3] in 1896, divides adhesions into 4 groups, in the following order of frequency: (1) the adhesions around the gall-bladder region; (2) adhesions around the cæcum and apendix: (3) adhesions of the sigmoid and (4) pelvic adhesions. Robinson[4] in the same year reported observations tending to show that the viscera most frequently involved were in their order of frequency as follows: (1) spleen, (2) the mesacolon, (3) the pelvis, (4) the cæcum and appendix, and (5) the gall-bladder region.

Bryant,[5] in a recent report gives detailed careful observations upon 200 unselected consecutive post-mortem cases, of all ages and sexes. The only cases excluded being those few of recently post-operative origin or those exhibiting recent frank peritonitis. The age of 40 was found to be a critical one for both sexes. There is practically no increase in frequency above the fetal rate of involvement for the different viscera until the age of 40 is reached. Beyond this age there is a sudden increase of about 50 per cent. in the involvement of the different viscera by adhesions. The two actual adhesions or bands found to occur most often in both sexes and at all ages in order of frequency as follows: (1) gall-bladder to the duodenum and to the transverse colon in both sexes; (2) the gall-bladder to the transverse colon in the male and the gall-bladder to the duodenum in the female. In the studies of the male and female fetus, the two adhesions or bands most frequently found were: first, the gall-bladder to the duodenum and to the transverse colon; second, the gall-bladder to the transverse colon alone. It would appear therefore that these two most frequently occurring adhesions or bands are of congenital or developmental origin or due to inflammation during fetal life. The region or quadrants of the abdomen most frequently involved by adhesions or bands in both sexes are, according to Bryant, in the following order of frequency: first, right upper quadrant; second, right lower quadrant; third, left upper quadrant and fourth, left lower quadrant.

In this study, we found that there were four deaths in each series or 8 in all. Two cases in early middle life died from cardio-renal insufficiency after difficult cholecystectomies, 1 including removal of stones and drainage of the common duct.

Two cases, complicated by bowel perforation, died from shock and peritonitis within 24 hours. This makes the 4 deaths in the 75 cholecystectomies or 5.3 per cent.

In the drainage series the first patient died of peritonitis 10 days after operation for gall-bladder disease, and in which it was necessary to do a resection for gangrenous intestine. The second death was in a case of empyema of the gall-bladder, which was drained 3 weeks after marked sepsis had set in. There was a rise in temperature, pulse rate and respiration and a violent death within 24 hours. The third death was a case showing streptococcus in bile drainage. Death followed from cardio-renal insufficiency. The fourth death came 5 days after first operation. Death 24 hours later was due to cardio-renal complications also.

The mortality percentage of the series was 6.1 per cent.; that of the drainage case 7.2 per cent. Of immediate operative results noted when leaving the hospital 39 were well or apparently cured, .75 were listed as improved, while 8 were unimproved.

A follow-up study 18 months after the discharge from the last patient of the series showed the following:

Eighty of the 130 patients responded in person or answered the questionnaire. Of these the ratio of cholecystectomy cases was 5 to 3 for drainage. Two drainage cases had had but very temporary relief from symptoms; 1 having return of symptoms 5 weeks after discharge, the other 6 months after discharge. Another drainage case was re-admitted re-opened and found to have malignancy of the liver, death following shortly afterward. The secondary cholecystectomy case showing a biliary cyst and extensive adhesions about the common duct was re-admitted to the hospital, and died after a third operation. One cholecystectomy patient, aged 75 at time of operation, was reported as dead in the returned questionnaire, but the cause of death was not given.

All of the remaining 75 patients who responded, exhibited or reported good health and enthusiasm for their operative results.

SUMMARY

SECONDARY CASES—TOTAL 11

Following cholecystectomy—2

Case I.—Age thirty-three. Gall-bladder removed 5 years ago; recurring symptoms 1 year. Choledochostomy.

Case II.—Age forty-eight. Cholecystectomy 4 years ago; recurring symptoms 6 months. Biliary cyst drained. Obstructed common duct freed.

Following drainage—9

Case I.—Age forty-one. Return of symptoms 1 year after operation 10 years ago. Cholecystectomy and freeing of extensive adhesions.

Case II.—Age forty. Return of symptoms a few weeks after operation. Cholecystectomy with freeing of adhesions.

Case III.—Age twenty-seven. Return of symptoms 1 year after operation, with stones found at second cholecystectomy.

Case IV.—Age thirty-five. Adhesions freed at second operation.

SUMMARY.—*Continued*

Following drainage—9

CASE V.—Age thirty-nine. Previous operation 10 years ago. Cholecystectomy with stones.

CASE VI.—Age forty-three. Stone removed at drainage 5 years ago. Return of symptoms 1 year ago. Cholecystectomy, adhesions freed.

CASE VII.—Age forty. Drainage 3 years ago. Relief for 1 year. Cholecystectomy with adhesions. Drainage 5 years ago, with relief for 6 months. Cholecystectomy with adhesions. Stone in cystic duct.

CASE IX.—Age twenty-nine. Drainage 1 year ago. No relief of symptoms. Cholecystectomy with adhesions.

DEATHS

Cholecystectomy—4

CASE I.—Age thirty-six. Cholecystectomy with extensive adhesions. Died of kidney insufficiency.

CASE II.—Age sixty-two. Cholecystectomy with duodenal perforation. Died of peritonitis.

CASE III.—Age fifty-four. Cholecystectomy with colon and duodenum perforated by large block stone. Upper gall-bladder communicated with colon. The lower gall-bladder with duodenum. Suture of perforations. Death within 24 hours from shock.

CASE IV.—Age forty-three. Cholecystectomy with stone from common duct. Head of pancreas indurated. Death from progressive weakness.

Cholecystostomy—4

CASE I.—Age forty-nine. Cholecystostomy with marked empyema. Violent T. P. R. Duration before operation 3 weeks. Death in 24 hours. Sepsis progressive.

CASE II.—Age fifty-six. Cholecystostomy with stone in cystic duct. Death 5 days after operation. Cardiac death with sepsis.

CASE III.—Age sixty. Cholecystectomy. Bile showed streptococci. W. B. C. 17,000. Cardio-renal death.

CASE IV.—Age fifty-two. One large stone removed at drainage. Drainage tube pulled out 5 days after operation by patient (delirium). Resection of gangrenous gut 10 days after operation. Death followed this within 24 hours from peritonitis.

Percentage of deaths: 6.16 per cent.

Operative results:

Well apparently	39
Improved	75
Unimproved	8

CONCLUSIONS

1. Cholecystitis may have its origin in vague beginnings in early life, but is clearly recognized and routinely treated in or past middle life. The average duration of clear cut symptoms was slightly over 2 years, while the average age of the patient in our series of 130 consecutive cases was 44 years.

2. Widespread, definite and troublesome adhesions with bands from gall-

bladder to duodenum and transverse colon were the most uniform finding in all types of cases.

3. Seventy-five cases were treated by cholecystectomy, with 4 deaths encountered from this series.

4. Forty-one cases were treated by drainage methods, with 4 deaths. Deaths in both series were due to cardio-renal failure or peritonitis in complicated (stone cases).

5. The mortality percentage was 6.16 per cent. Of 11 secondary cases, 2 followed cholecystectomy, 9 followed drainage procedures.

6. In the follow-up data, the cholecystectomy cases were freer from symptoms and maintained their regained health more constantly.

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LYMPHO-SARCOMA OF THE SMALL INTESTINES

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Lympho-sarcoma of the gastro-intestinal tract is reported in the literature as being found in every segment from the stomach to the rectum, but seems to show a marked predilection for the ileal division of the small bowel. While of relatively infrequent occurrence as compared with carcinoma throughout the entire intestinal tract, it perhaps is found as frequently in the small bowel as any form of malignancy. Broders and Mahle recently reported twelve cases of lympho-sarcoma of the stomach giving its incidence in comparison with carcinoma as 1 to 68. Their review of the literature showed only one other series as large as their own, with scattering reports of an occasional case from various sources. The literature shows reported cases in the small bowel and colon to be approximately 300; several relatively large series having been collected by various writers, among them those of Libman and Crowther. Krugerz Boaz collected 37 cases of sarcoma of the intestines which were distributed about equally between the large and small bowel; the rectum, however, being the site of a malignancy in 16 cases. DeNoyelles cites the relative frequency of this disease as compared to carcinoma as 1 to 20. The striking similarity in the distribution is noted when it is seen that the rectum and ascending colon, as in carcinoma, are the most frequently involved segments of the large bowel.

Gerster and DeNoyelles report cases in the small bowel occurring high in the jejunum and an occasional case involving the ileum, ileo-cæcal valve and the cæcum. Crowther reports 12 cases occurring in the duodenum in a series of 191 cases, and Libman's review found 15 additional such cases in the same location.

Symptomatology.—Unfortunately this condition is rarely diagnosed prior to operation and its most frequent recognition comes at the autopsy table. There seems to be no single line of symptoms which constantly occurs in these cases. Either the attack is ushered in simulating an acute fulminating abdominal infection, which is usually diagnosed acute appendicitis, or as is more usual the findings of constitutional symptoms of anæmia, cachexia, and weakness predominate. Ochsner describes the early symptoms as indefinite abdominal pain which persists and is not relieved by rest and starvation, as is the case in the usual chronic abdominal infections. The character of the pain is colicky; there is slight if any tendency to localize in any one definite spot. The fact that stenosis of the bowel does not occur until glandular involvement from the outside causes partial intestinal obstruction, militates also against an early diagnosis. Ulceration being rare in the beginning of this disease, whose pathology is located first in the submucous coats of the bowel, precludes

X-ray assistance being of much value in early diagnosis. The bowel not infrequently is dilated proximal to the tumor because of paralysis of the musculature from direct invasion of the malignancy. The fact that there is a dilatation of the bowel about the growth rather than a stenosis produces an intermittent obstruction which probably accounts for a more constant chain of symptoms than any other one single factor. In the advanced stage of the disease where tumefaction is distinctly evident, obstruction is most likely to occur and a diagnosis of malignancy be made, but without hope from surgical intervention. Cases are reported in which there has been an intussusception present which produced partial obstruction, anorexia, and bloody diarrhœa. In one of our own cases the tumor mass extended into the cæcum through the ileo-cæcal valve and the attempt of the bowel to rid itself of this bolus produced an intussusception with partial obstruction which was diagnosed acute appendicitis with abscess. In the chronic type of case the tumor mass, which is usually irreguiar and probably most often due to lymphatic involvement in the mesentery, is variable in its location and usually of a not too firm consistency. The latter condition when cachexia has taken place and metastases are evident, must be differentiated from peritoneal tuberculosis, carcinoma, and the granulomata.

FIG. 1.—Case I. Gross specimen; most marked portion of tumefaction is in ileum; cæcal band is distinctly shown.

The age of the individual should have some bearing upon the diagnosis—a sarcoma always being looked upon as a disease of early youth or young adult life. The distribution as far as sex is concerned is about equal. One of our own cases was a young man and the other a middle-aged woman. The age incidence, however, is distributed over the first to the fifth decade. The prognosis is always gloomy; recurrence is rapid despite any treatment available, and Baltzer quotes the duration of the disease as less than one year from its time of onset.

Pathology.—Pathologists agree that lympho-sarcoma of the bowel begins in the lymph follicles and may be either of a primary or secondary nature. The gradual extension of the growth into the mucosa and the other bowel coats, except the peritoneal one, is progressive. This extension rarely causes perforation and resulting peritonitis. The ulceration through the mucous mem-

brane, however, occurs in a relatively high percentage of cases. Occasionally pedunculated growths are found. The microscopic picture is consistent. The type of cell which predominates usually resembles the lymphoid cells of the mucosa, of which there are many variations. In the cases reported by DeNoyelles the predominating cell resembled the transitional mononuclear cell of the blood. Bunting and Huston show that the lymphocytes in the blood stream migrate into the intestinal mucosa to function normally. Other writers suggest that these lymphoid cells in the presence of some irritation proliferate wildly, and DeNoyelles suggests that a chronic irritation, possibly a specific toxin, played an important part in the genesis of lympho-sarcoma. Because of the histological resemblance to an infectious granulomata he suggests that lympho-sarcoma "Is one of the many bizarre later pictures of lesions which were at one time of the nature of Hodgkin's disease, or lymphoblastic or lymphocytic leukæmia." The lymph-glands which are early infected grow rapidly and frequently attain the size of walnuts. Their pressure upon the neighboring loops of bowel occasionally become sufficient to produce obstruction. The invasion of the mucous coats by the tumor itself causes paralysis and distention rather than stenosis.

FIG. 2.—Case I. Gross specimen opened and showing the protrusion through the ileo-cæcal valve into the lumen of the large bowel.

Treatment.—Treatment by whatever methods undertaken usually yields unsatisfactory results. If the diagnosis be established before too much lymphatic invasion has taken place, surgery seems to offer the best chance of cure or at least the most palliation. Where the process is extensive and where a resection would involve the sacrifice of too wide an area of bowel substance palliative measures such as sidetracking operations are indicated. Radium in certain sarcomatous cases has given such excellent results that some observers have been stimulated to urge its use in this condition. Certainly

the end results from surgery are poor, even from the standpoint of prolongation of life, to urge it as other than a last resort. Under any of the present day treatments the prognosis is poor, and unless the early diagnosis of this condition can be made there is relatively little chance of instituting other than palliative measures. It is suggested that radiological evidence may be of greater value in an early diagnosis of these lesions under a more improved technic than we have at present. When we know the number of cases of sarcoma of the small bowel reported and consider their uniformly fatal outcome a short time after being discovered, and where an exhaustive study of the clinical syndrome or laboratory investigation have disclosed nothing helpful except the after-thought that X-ray examination might have found the lesion earlier, it is evident that the opaque meal should not be restricted so largely to cases in which carcinoma of the stomach or large bowel is suspected.

FIG. 3.—Case II. The gross specimen of the resected small bowel showing where the attachment and perforation took place.

The insidiousness of the disease and its lack of a consistent symptom-complex seem to show conclusively that we must look to the röntgenologist for progress in making an earlier diagnosis, if we are to reduce the mortality by any therapeusis now available. Appended are the case reports of two cases which came under our observation and were operated during the same week in 1923.

CASE I.—H. R., male, age thirty-one, laborer. Chief complaint: Pain in right side of abdomen; marked constipation for six weeks. Family history: Negative.

Personal History.—Measles and whooping cough in childhood with complete recovery; pneumonia ten years ago; typhoid fever four years ago, no complications or sequelæ with either. General health good. Otitis media eight years ago, short duration and no recurrence. Frequent toothache. No dyspnœa, œdema or cough. Frequent drenching night sweats, have been common during both winter and summer for many years. Appetite always good; no jaundice; troublesome constipation for six weeks previous to admission. Frequent and urgent urination for last six months. Nervous system negative. Best weight 165; average and weight on entrance 163 pounds.

Present Illness.—Patient felt perfectly well until six months before coming into the hospital. At that time he began having vague abdominal discomforts which he

describes as indigestion. Cramping sensations would be frequently experienced after the drinking of cold water or after ingesting a heavy meal. This would be evident sometimes before the meal would be completed. The occurrence of this uneasiness was dependent on the size of the meal rather than upon any particular articles of food. It would be felt most plainly in the lower right quadrant of the abdomen and would persist from thirty minutes to two hours after eating. This phenomenon was noticed about two-thirds of the time. Eructation after eating was common. Small quantities of food were occasionally regurgitated but no true vomiting occurred. During the five weeks previous to admission a constant, dull pain had been present in the right lower quadrant. This was aggravated by walking or bending over. This condition became progressively more annoying up to the time of admission. Pain and sensitiveness were then so marked over the affected area that the patient was hurried to the hospital at seven o'clock Thanksgiving evening.

FIG. 4.—Case II. The specimen cut open showing the inside of the bowel lumen.

Physical Examination.—Temperature 100.5, pulse 105, respiration 24. Well developed and nourished white male thirty-one years old. Mucous membranes gave evidence of moderate anemia. Facial expression anxious. Teeth in poor condition. Tongue lightly coated. Neck, heart, and lungs negative. Abdomen: Distinct fulness in right lower quadrant. No intestinal patterns seen. Rigidity present over lower half of the abdomen, more marked on right. A tender mass was present over the cæcal region with acute sensitiveness over McBurney's point. This mass was ovoid, fluctuant, and felt to be about the size of a grape fruit. Abdomen negative otherwise. Rectal negative.

Laboratory Blood Examination.—Red blood cells 4,000,000, leucocytes 11,000, polymorphonuclears 68 per cent., urine negative.

Diagnosis.—Suppurative appendicitis, localized abscess. Immediate operation advised.

Report of Operation.—Right rectus incision made. Large tumor mass was found involving the terminal ileum and cæcum. Enlarged glands were present in the mesentery in this region. The terminal ileum for a distance of about eight inches, the cæcum and ascending colon were removed, and the terminal portion of remaining ileum was anastomosed end-to-side to the colon. All of the enlarged glands could not be removed. Abdomen was closed without drainage and aside from a wound infection the patient made an uneventful recovery from the operation.

Four months later, the patient returned to the hospital on account of return of abdominal discomfort, dyspnœa, and increase in girth of abdomen. Examination of abdomen disclosed masses that were probably the result of continued growth of the neoplastic process.

Gross Description.—Specimen consists of a portion of ileum, cæcum with attached appendix, and portion of colon. The junction of ileum with colon is distorted and changed from its normal appearance due to an invasion of the wall of the intestines with a tumor mass. The appendix is 140 x 16 mm. adherent to the intestine with a firm, fibrous adhesion. Two centimetres toward colon from origin of appendix, the mucosa contains a fairly smooth, rather firm, elevated tumor mass, about 30 mm. in diameter which tends to circle the colon and extends well into the submucosa. From this mass the wall of the intestine to the appendix and backward toward ileum, averages 22 mm. in diameter, being infiltrated with a pale gray, fairly firm, somewhat homogeneous tumor mass. About 3 cm. from origin of appendix toward the ileum, the tumor mass extends out into the lumen in a circular manner almost occluding the lumen of the intestine. The wall of the intestine toward the ileum is invaded 12 cm. from origin of appendix from which place the ileum and its mucosa appears normal. The wall of the intestine toward the colon is invaded 5 cm. from appendix from which place mucosa appears normal. The mucosa of the intestine over the area of tumor invasion of its wall (between areas of normal mucosa of ileum and colon) is dull purplish-red, roughened and indistinct as to its normal markings.

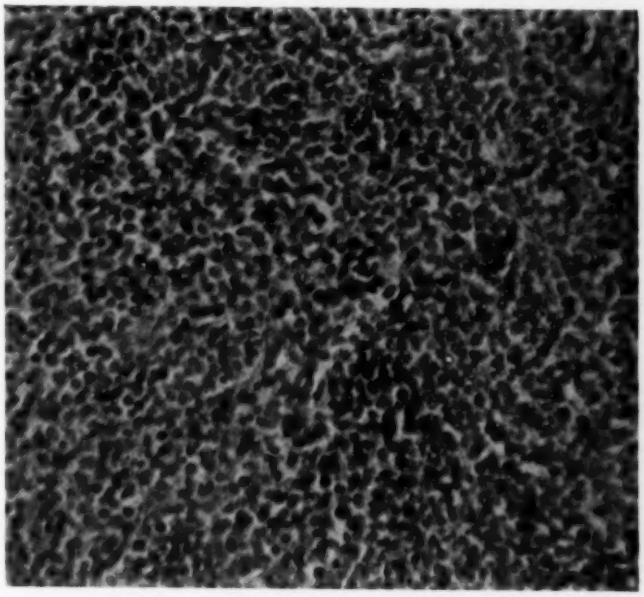

FIG. 5.—Microphotograph from a section of Case I, showing delicate connective-tissue stroma supporting typical lymphoid cells.

(2) Portion of mesentery contains few lymph glands which are fairly firm, dull red and on section varies from pale gray to purplish-red with loss of normal appearance of lymph gland. Cut surface resembles somewhat rice in water with dark shaded colors. The glands average 20 mm. in diameter.

Microscopic Diagnosis.—Lympho-sarcoma.

CASE II.—M. M., age forty-nine, housewife. Patient was a Slav with but slight knowledge of English so that only a scant anamnesis could be obtained. Chief complaint: Pain in lower right side of abdomen. Family history: Negative as far as obtained.

Personal History.—No pulmonary troubles that were at all chronic. Patient was able to do a full day's work up to the time of coming in to the hospital. She had suffered with constipation for the four years preceding. Never jaundiced. Frequency and burning on urinating for six weeks previous to admission. Patient had been pregnant thirteen times, twelve of which terminated normally and one miscarried. The menopause occurred six years before admission.

Present Illness.—Two months before coming into the hospital patient experienced generalized pain in the whole lower abdomen. This persisted for about a week and then became localized in the lower right quadrant. It has been constant there since. Patient has vomited three times during this whole period.

Physical Examination.—Patient is a moderately well nourished white woman forty-nine years old, and is in obvious discomfort. Color is fair. Head, eyes and nose negative. Oral sepsis present. Pharynx and neck negative. Thorax: Antero-posterior diameter increased. Percussion note hyperresonant to 4th rib anteriorly and impaired with limited expansion at both bases. Breath sounds indistinct with occasional moist râles at both bases posteriorly. Heart: Sounds muffled, otherwise negative. Abdomen: Generalized distention. Somewhat tender throughout, most marked in lower right quadrant with a second area of slightly increased sensitiveness in upper part of upper right quadrant. A mass was palpable in right side just below umbilicus and apparently extending into pelvis.

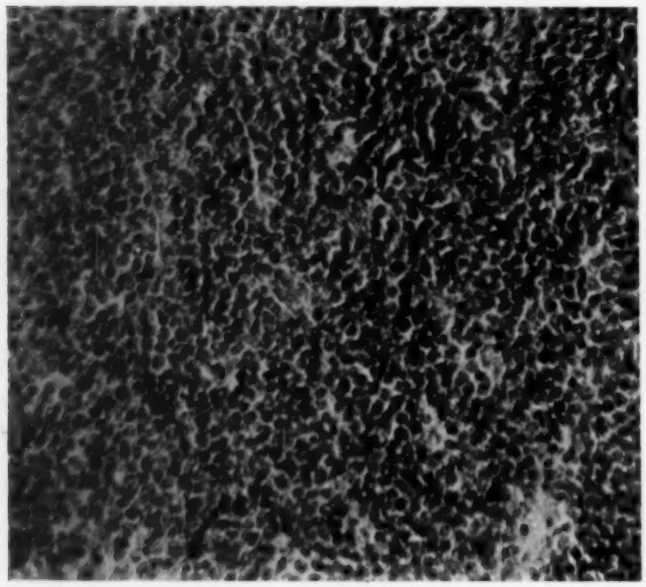

FIG. 6.—Microphotograph of Case II. Picture similar to Case I.

Vaginal Examination.—Outlet relaxed. Yellowish discharge present. Cervix lacerated and pointed up to symphysis. Uterus turned back. There was a smooth mass extending from uterus up into region of cæcum. This was quite adherent and manipulation brought forth such protests from the patient that thorough examination could not be made at the time. A tentative diagnosis of fibroid tumor with dense adhesions of bowel was made. Under anæsthesia, however, it was found that the pelvic tumor could be moved somewhat without disturbing the position of the uterus to a corresponding extent and appeared to be primary in region of cæcum.

Laboratory Data.—Urine negative. White blood cells 7,200 with 75 per cent. polymorphonuclears.

Diagnosis.—Tumor of cæcum with adhesions to pelvic organs.

Operative Findings.—Right rectus incision made. A tumor of the small gut was found situated about 10 inches from the cæcum, densely adherent in the pelvis and stuck to back of uterus. During delivery from pelvis it was opened at one point. It was resected together with six inches of normal bowel on the proximal side and four inches on the distal side. Numerous hard glands were present in the mesentery. An end-to-end anastomosis was made with catgut and silk. About ten inches proximal to the anastomosis and ileostomy was done after the method of Witzel. No metastases other than glandular were made out. Abdomen closed without drainage. The patient rallied and did well for several days but died on the twelfth day.

Partial autopsy showed no peritonitis. The anastomosis was healed. Numerous lymphatic glands throughout the bowel mesentery were found to be invaded. Death was due to bilateral broncho-pneumonia.

Description of Specimen.—Gross: Specimen consists of portion of small bowel with attached mesentery and lymph-nodes.

(a) Forty millimetres from one end of the gut. The gut wall is enlarged into a tubular mass, incised, 50 mm. in diameter and total length of 140 mm. which is firm,

yellowish to pinkish-gray and mottled with red. On section, the wall of the tubular mass is 20 mm. thick and is lined with a purplish-red mucosa, wall of which measures 3 mm. in thickness. Mucous surface of normal gut is pinkish-gray, mottled with red. Cut surface shows 18 cm. of gut with apparently normal mucosa, while the remainder shows no evidence of folds in the mucosa, and is rather smooth and pale to deep reddish-gray. The wall of latter portion is 8 to 20 mm. thick, gray, firm and contains a few fibrous striations.

(b) Attached mesenteric lymph-nodes which vary from 6 to 35 x 20 mm. moderately firm. Cut surfaces vary in being gray, yellowish-gray and light brown. All are moderately smooth.

Microscopic Diagnosis.—Lympho-sarcoma.

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URETERO-PYELOGRAPHY

A CRITIQUE ON ITS USE AS A DIAGNOSTIC PROCEDURE

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Some opposition has arisen as to whether this comparatively recent addition to our diagnostic resources should be more or less routinely employed in the examination of a patient suspected to be suffering from a lesion of the upper urinary tract. It is with the object of replying to these objections that this paper is written.

Is uretero-pyelography a safe procedure? In order to answer this it is necessary to review the history of the method briefly. In 1906, Voelcker and Lichtenberg first suggested the injection of collargol into the renal pelvis through the ureteral catheter with the aid of a syringe. During the next ten years pyelography was employed comparatively seldom because of the reports of the ill effects and even deaths following its injection. A number of other media were next suggested as substitutes, such as argentide, pyelon, etc. These like collargol all belonged to the group of colloids. Selms[1] in 1920 collected 17 deaths following pyelography and this knowledge caused many to abandon the method altogether or to employ substitutes which were not of a colloidal nature like thorium.

Experimental work revealed the fact that some of the deaths following the use of the silver preparations (like collargol) were due to two factors: (a) The use of too much pressure in injecting the solution so that it not only was forced into the renal parenchyma, but by way of the veins of the kidney into the general circulation and caused death[2] in animals, at least, from pulmonary embolism. (b) The toxic effect of the preparation *per se*. It was found that colloids like silver entered the renal tissues more readily than solutions of crystalline substances and this explained some of the deaths or other ill effects even when but little pressure was used in injecting the solution.

Following the report, however, of deaths after thorium had been injected into the renal pelvis, even this medium was discarded. A new era began with the suggestion that solutions of the halogen salts, such as the iodides and bromides be used as substitutes for the more easily dialysable colloids. It was then found that potassium iodid, even in a relatively weak solution, was too irritating to the renal pelvis and so sodium bromide in 15 to 30 per cent. strength was suggested as a substitute and is still extensively employed abroad.

Although there were less ill effects following the injection of sodium bromide solutions, the intensity of the shadow left much to be wished for. A 12½ per cent. solution of sodium iodid gives just as intense a shadow as the solutions of the potassium salt but has the advantage of being isotonic and hence far less irritable to the mucous membrane of the ureter and renal pelvis. The majority of urologists now employ the sodium iodid in the

above-mentioned strength. It has the advantage of being non-toxic so that relatively large quantities can be employed without the danger of the toxic effects following the absorption from the renal pelvis of such media as the silver preparations, thorium or even solutions containing any of the potassium salts.

The technic which is most frequently employed is the following:

Preparation of the Patient.—No special preparation aside from that incident to the radiography of the urinary tract is needed. Special stress should be laid upon the necessity of abstaining from the ingestion of food and of much liquid for six hours, at least, before the use of the sodium iodid solution. Even sterile water injected into the renal pelvis of some individuals will cause reflex nausea, vomiting and even symptoms of collapse, and these will be greatly decreased if the alimentary tract is empty.

Injection of the Solution.—Too much emphasis cannot be placed upon the importance of injecting a solution warmed to near body temperature, slowly and with but little pressure. It is not necessary any longer in my opinion to employ the gravity method nor to insert a manometer between the syringe and ureteral catheter. I first aspirate the contents of the renal pelvis and then inject 7 to 10 c.c. of the solution with an ordinary Luer syringe after having introduced a No. 5 or No. 6 ureteral catheteral whenever possible as high as the renal pelvis. The best indicator that enough solution has been injected to distend the renal pelvis is the degree of resistance to any further injection. If the patient does not complain of pain and there is no resistance, it is perfectly safe to continue to use more of the solution until there is distinct resistance or one can stop when 50 or 60 c.c. have been injected, to take the first picture and wait until it is developed before injecting any more solution. The first exposure is made while the catheter is inserted either into the renal pelvis or lies at the level of an obstruction in the ureter. The catheter is next withdrawn until it lies near the lower end of the ureter and a second exposure made after injecting enough solution until resistance is again encountered. The third exposure is made about one hour, if possible, after the first one to ascertain whether there is any retention in the renal pelvis or ureter as is so often seen in cases of ureteral stricture. Ordinarily we only make exposures when the patient is in a horizontal position, but if there is any suspicion of a movable kidney, the patient must be raised to the vertical position by elevating the X-ray table at one end before the catheter is withdrawn from the ureter in order that an exposure may be made to determine the degree of mobility of the kidney and a kinking of the ureter. If possible all of the solution should be permitted to escape before the ureteral catheter is withdrawn. I do not hesitate to make a bilateral exposure at the same sitting, provided that the solution is allowed to escape or is aspirated from one side before the second is injected. An unobstructed renal pelvis or ureter empties within a few minutes as one can readily observe if a series of exposures are made at the same sitting. It is always advisable in cases where

there is retention within the renal pelvis to aspirate the turbid urine or more purulent contents before the pyelographic medium is injected.

Uretero-pyelography should never be employed in cases of acute renal infection or where a cystitis is so severe that even ureteral catheterization is a menace. In the latter class much valuable information can be obtained as to the condition of the upper urinary tract by studying the question of ureteral reflux in a cystogram.

That there are ill-effects in some cases following the injection of even the isotonic 12½ per cent. of sodium iodid solution cannot be denied. These, as a rule, are transitory and not alarming. It varies greatly with the individual case. In some, colicky pain, nausea, vomiting and other reflex symptoms are not uncommon, but yield to simpler remedies. Although cases of hæmaturia, at times quite persistent, followed the use of iodid of potassium solutions, I cannot find any report of such sequel after sodium iodid. The only report of a fatal result since the use of the halogen solutions is that of Neergard [3] in 1922. A woman of forty-four, who had a latent bilateral pulmonary tuberculosis of many years' standing and a thyroidectomy five years before, was examined as to the origin of a tumor in the right upper quadrant of the abdomen. The indigo carmin excretion from both kidneys was very poor. Fifteen c.c. of a 10 per cent. solution of potassium iodid was injected into the right and 10 c.c. of the same strength into the left renal pelvis. It was allowed to escape through the catheters after the pyelography. Death occurred twenty hours later. The autopsy, including a microscopic and chemical study, failed to reveal the cause of death.

That potassium salts *per se* may act on the heart muscle has been shown experimentally, but it would hardly seem as though this played a part in the above case. As was stated earlier in this paper, the use of potassium iodid is pretty generally abandoned, so that the question of danger from this source can be excluded in the future. The poor condition of Neergard's patient is a warning, however, to study a case thoroughly before pyelography is done as a routine measure.

Reports of cases such as the one of Morton's, where anuria followed bilateral pyelography are not free from the criticism that the ureteral catheterization *per se* might be responsible for the anuria. I have recently seen such a case in consultation, the anuria lasting about 36 hours. Reflex anuria during unilateral ureteral catheterization alone is not rare at all.

Aside from Neergard's case, no other serious ill-effects have been reported following uretero-pyelography since the employment of the halogen salts. With the adoption of a more or less standardized technic of injection and the use of isotonic solutions such as 12½ per cent. sodium iodid, we have entered a new era in the history of this diagnostic method, an era which I feel confident will demonstrate that it is as safe and necessary a procedure as ureteral catheterization or lavage of the renal pelvis, both of which have been epoch-making in the history of urology.

Is uretero-pyelography a necessary procedure? Those who oppose this method assert that it does not afford information which is not given by other diagnostic methods. In order to answer this it is necessary to take up the principal lesions of the upper urinary and to compare the data yielded by the study of a case before and after uretero-pyelography. I have expressed my views in a recent paper [4] in which the importance of uretero-pyelography as an aid to abdominal diagnosis in general was emphasized.

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CONGENITAL PERINEAL TESTICLE

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By congenital perineal testis is meant an anatomical abnormality which is characterized by the presence of a testis within the boundaries of the male perineum at birth.

On account of the rare occurrence of this anomaly it occurred to the writer that the following case report would be of interest; and that it would be fitting to present therewith a new interpretation of the etiology of ectopic testes.

Case Report.—The patient, a youth eighteen years of age, came to the Cleveland Clinic because of discomfort due to a mass in the perineum. Since birth the right side of the testis sac had been atrophic and unoccupied whereas the left side had been normal in appearance and occupied by a normal testis. Always within the memory of the patient there had been a lump in the right side of the perineum just anterior to the anus. This lump had always been movable to a certain degree. It had been the site of considerable discomfort and on many occasions of actual pain, particularly when sudden pressure had been brought to bear upon it.

Physical examination showed a well developed, well nourished, apparently robust youth with clear skin, 5 feet, 8 inches in height, 140 pounds in weight. The right half of the testis sac was normal in appearance and occupied by a testis of normal size. (Fig . 1, a.) In the perineum, 2.5 cm. in front of the anus and just lateral to the median perineal raphé was an ovoid mass which in size and shape corresponded to the left testis. (Fig. 1, b.) This perineal mass could scarcely be moved posteriorly and its range of freedom from side to side was restricted.

Anteriorly, however, the mass could be pushed up to the corresponding descending ramus of the pubis but could not be manipulated into the subcutaneous inguinal ring. Pressure upon the mass elicited a sensation of pain, which corresponded in character with the pain elicited by the application of similar pressure upon the normally situated left testis. Diagnosis of congenital perineal testis was made.

The operation of orchidopexy was performed by Dr. William E. Lower as follows: Under light nitrous oxid oxygen anæsthesia and local novocaine anæsthesia an incision extending from the subcutaneous abdominal ring to the scrotal neck on the right side was made through the skin and superficial fascia so as to expose the right spermatic cord. With the cord as a guide the fingers were moved backward into the perineum to the testis. An index finger was hooked around the testis and the latter which was only slightly adherent was brought out upon the thigh. Examination of the testis and cord revealed no patent processus vaginalis—in fact the tunica was normal. A bed for the testis was then prepared in the right half of the scrotum by introducing two fingers and stretching the tissues vigorously in all directions. After this was done the testis was picked up and dropped into the bottom of the cavity that had been made for it. There it rested without tension for the spermatic cord was of ample length. No. 1 plain catgut was used for hæmostasis. Closure was made and a supportive dressing applied.

The patient made an uneventful recovery and left the hospital on the eighth day after the operation. He was seen again three months later when the testis was found to be where it had been placed in the bottom of the testis sac and there was no evidence of post-operative atrophy, though the right testis was still slightly smaller than the left as it had been before the operation. (Fig. 1, c.)

A review of the indices of medical literature relative to this subject warrants the assertion that this anomaly is very uncommon, more uncommon in fact than one is at first inclined to believe. That this is true is obvious because among 92 sporadic case reports of perineal testis many are found to have been of traumatic rather than congenital origin. Coley[1] states that Annondale in 1879 was the first to report the successful surgical treatment of a case of perineal testicle.

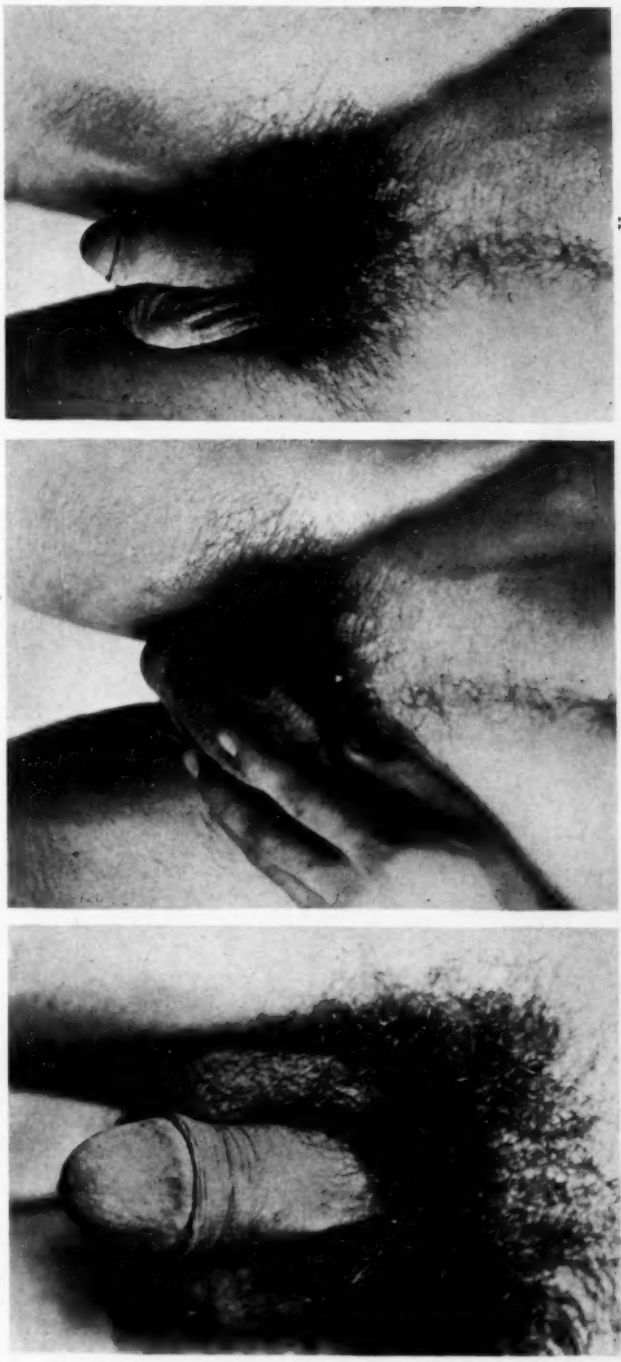

FIG. 1.—Case of perineal testicle. A, appearance of scrotum containing left testicle. B, ovoid mass in perineum. C, post-operative appearance after orchidoplasty.

Authorities are not in agreement regarding the etiological factors which may influence the production of congenital perineal testis. Heredity has been mentioned as an etiological factor and Godard [5] speaks of an instance in which perineal ectopia was present in father and son.

In 1786, John Hunter,[6] in an essay entitled "A Description of the Situation of the Testis in the Fœtus, with its Descent into the Scrotum," makes the following statement: "The testicle in changing its situation does not always preserve a proper course towards the scrotum, there being instances of its taking another direction and descending into the perineum. How this is brought about is difficult to say; it may possibly be occasioned by something unusual in the construction of the scrotum; or more probably, by a peculiarity in the perineum itself; for it is not easy to imagine how a testicle could make its way to the parts about the perineum if these were in a perfectly natural state."

In 1887, Lockwood [8] studied undescended and maldescended testes and emphasized the etiological importance of the multiplicity of the distal insertions of the gubernaculum testis. He conceived that during the sixth and seventh months of fetal life the fibres of this structure pass through the distal portion of the ventral abdominal wall by way of the inguinal canal and the subcutaneous inguinal ring, thereafter undergoing division to form the several so-called tails. He assumed that one of these tails extended to the pubis at the root of the penis, another to the bottom of the scrotal sac and the third to the perineum ending either by fixation to the tuberosity of the ischium or by intermingling with the fibres of the perineal body. On the basis of this conception, Lockwood believed that the gubernaculum was the factor of chief importance in the phenomena of descent of the testis and that the various types of congenital dislocated testis were due to the excessive development of some one of these gubernacular tails.

This theory that Lockwood advanced so many years ago has served as a simple and unusually popular solution for a problem otherwise unsolved and as such has been widely quoted. In considering the reliability of this theory one is inclined to question whether or not multiple gubernacular tails ever do occur. If we turn for corroborative evidence to the mass of data assembled by investigators in embryology we do not find it, and if we search anatomical monographs for references to multiple gubernacular processes there likewise we fail to find them. Since modern embryological and anatomical treatises do not include any statement regarding the principle upon which Lockwood based his theory, its tenability would seem to be questionable.

In view of the apparent lack of evidence in support of Lockwood's theory, the author desires to offer for the first time a suggestion as to the etiological factors which he believes to be active in the production of ectopia testis, his views being in harmony with modern embryological and anatomical knowledge.

At an early period of embryonic development the mesoderm forms a wedge-shaped plate between the ectoderm and the entoderm on either side of the medullary tube and notochord. The base of this wedge is directed medially and lies adjacent and parallel to the medullary tube. The edge of the mesodermal wedge is its lateral border. Each of these mesodermal plates rapidly differentiates into a medial, an intermediate and a lateral portion by virtue of a longitudinal constriction which appears in its substance close to the thick medial border. The most medial portion is the paraxial mesoderm and the most lateral portion is the lateral plate. Of prime importance in this connection, however,

is the constricted portion of the mesodermal wedge which lies between the paraxial and the lateral mesoderm. It constitutes what is known as the intermediate cell mass (genonephostome) and from it are derived the tubules of the three excretory organs in rapid succession and finally the internal organs of the genital system including the testis, epididymus and vas deferens. In the course of development the intermediate cell tract substance finds insufficient space in the retroperitoneum and as soon as it begins to expand it bulges forward invaginating the cœlom wall as a fold into the cœlom cavity. Because from this fold are derived not only kidney substance but also reproductive gland substance it is called the *urogenital fold*. The urogenital fold begins in the fourth cervical segment and gradually extends toward the caudal end of the body cavity to about the fourth lumbar segment and in the course of its development undergoes a series of important changes. In the first place with the exception of the cranial and caudal ends it becomes divided, throughout its whole extent into a medial *genital fold* and a lateral *mesonephric fold*.

As soon as the reproductive gland (genital fold) is formed it becomes surrounded by a fossa, deep grooves cutting into it laterally and medially. The grooves on either side of the reproductive gland, however, never meet, a portion of the mesoderm persisting between them which gives rise to the stalk of the genital gland known as the mesorchium.

The maximum extension of the anlage of the reproductive gland is from the sixth thoracic to the second sacral segment, that is, over fourteen segments, but eventually it extends over only three or four segments, having degenerated from above downward over from ten to eleven segments. The caudal pole lies as low as or frequently lower than in the adult and accordingly the so-called internal descent of the testes never really exists. The cranial pole does indeed change its position, not, however, because it descends but rather because the upper three-fourths of the gland degenerates. Therefore, what seems to be a descent in reality is a shortening.

At first the urogenital folds are parallel to the vertebral column but as new organs appear between them in the middle line they become displaced. The growing suprarenal bodies force the folds of the opposite sides apart and what is initiated by the suprarenal bodies is continued by the metanephros and the intestinal tract. Caudal to the metanephros the spreading force ceases to act and the urogenital folds are not displaced but the occurrence of displacement above and its absence below produces characteristic bending of the folds. Distally, under normal circumstances the folds of opposite sides fuse in the midline to form the genital cord which is inserted upon the floor of the body cavity.

At about this period before the body wall has become entirely formed by the ventral bending and fusion in the midline there appears upon the lateral surface of the first bend of the mesonephros a knob-like outgrowth, the *inguinal fold* which reaches out in the direction of the rudimentary lateral abdominal wall. The lateral abdominal wall on its part at a point almost exactly opposite in the same horizontal plane, sends out a similar knob-like growth, *the inguinal crest* which is directed medially. The inguinal fold continues to grow in the direction of the inguinal crest and the inguinal crest continues to grow in the direction of the inguinal fold so that eventually the two meet and fuse. Thus, is established a connection which constitutes a bridge between the urogenital fold and the entrance into the inguinal canal. In the interior of the inguinal crest there is from the beginning a cord of compact mesenchyma, the *chorda gubernaculi* which is evident before there is any indication of a differentiation of the abdominal musculature. In transverse section it has a conical shape with its apex directed toward the inguinal fold and with its base almost at the integument. When later the abdominal musculature begins to develop it must grow around the chorda gubernaculi, thus forming the inguinal canal. The union of the gubernaculum with the mesonephric fold is exactly opposite the insertion of the ligamentum testis and in the portion of the mesonephric fold between these two insertions there develops another mesenchymatous cord which connects both with the ligamentum testis and the chorda gubernaculi. On the completion of this union there exists a continuous cord extending from the lower pole of the testis through the inguinal canal and terminating in the integument at the base of the genital tubercle, later the depths of the

scrotal sac. The chorda gubernaculi, therefore, is in effect a fibro-muscular cord which marks the path traversed by the testis in its descent from the abdomen. As we have stated, the exact manner in which the chorda gubernaculi exerts its influence has been a subject of dispute. It may be said, however, that its action is passive to a great extent although the active contraction of its smooth muscle constituents no doubt play an important part in bringing the testis first into the internal abdominal ring, then successfully to the testis sac.

The comparatively simple relations which have been described are altered by two processes. In the first instance the anterior body wall is brought from a horizontal to the vertical position and in the second instance the loops of intestine which lie in the exocœlom are taken into the body cavity. It is essential that space be afforded in the cœlomic cavity for the intestines and this is accomplished by the enlargement of its sagittal diameter which occurs synchronously with the ventral bending, thus increasing the space between the posterior and the anterior abdominal walls. These changes, however, do not come about without affecting the testis which we last mentioned as lying upon the posterior abdominal wall in the mid-lumbar region attached by a cord, the chorda gubernaculi, to the lateral, later the anterior abdominal wall. When the lateral abdominal wall begins to move forward the sagging in the chorda, if any exists, is taken up until this structure is stretched and taut. The lateral extremity of the chorda is firmly attached to the integument and the medial extremity is likewise firmly attached to the lower pole of the testis. The lateral abdominal wall continues to grow and bend ventrally toward the midline and in event the chorda does not break or pull out its insertions the testis must move from its bed and must of necessity follow the lateral abdominal wall and accordingly become more and more separated from the posterior abdominal wall. The caudal pole of the testis becomes directed ventrally by this pulling force and its long axis changes from a vertical to a horizontal position. Thus, the testis is passively moved in the direction of the internal abdominal ring while at the same time active influence is being exerted to the same end by the smooth muscle constituents of its gubernaculum. In the seventh month the testis wanders down through the inguinal canal (true descent) and the final position of the testis in the testis sac is acquired in the eighth month or at the latest before birth.

At the time of the descent of the testis into the scrotum during the eighth or ninth month of intrauterine fetal life, the structures which make up the ventral abdominal wall and fill the gap between the rami of the pubes are preformed and it is in fact upon the integrity of this preformation that the ultimate success of the testis in its manœuvring from the internal abdominal ring to the scrotal sac is dependant. Therefore, a brief discussion of the normal anatomy of the related parts will be attempted, with especial emphasis upon the connections of certain fascial planes.

Toward the lower part of the anterior abdominal wall the panniculus adiposus or superficial fascia which lies just under the skin develops special characteristics. In this locality it consists of two layers instead of one as is its character higher up. There is a fatty superficial stratum called *Camper's fascia* and a deep membranous stratum called *Scarpa's fascia*. The latter directly overlies the aponeurosis of the external oblique muscle. The superficial fatty stratum of Camper passes over the inguinal ligament and is continuous with the fatty superficial fascia on the front of the thigh. The relations of the fascia of Scarpa are very different and a comprehensive knowledge of its distribution is an essential part of the equipment of one who would understand properly the positions available to a testis which has so far succeeded in escaping from the subcutaneous abdominal ring but has thereafter been unable to find its way into the testis sac. If the fascia of Scarpa is followed distally over the abdomen it will be found that in the region of the pubes it passes downward over the spermatic cords, the penis and the scrotum into the perineum where it becomes continuous with the fascia of Colles. On the lateral side of the spermatic cord, that is, lateral to the tubercle of the pubes in the region of the groin, the fascia of Scarpa ends along the line of and immediately distal to the inguinal

ligament by fusing with the fascia lata of the thigh. The connections of the fascia of Scarpa are of extreme importance and it is desirable that they be fully understood. The practical demonstration of these connections as carried out in the dissecting laboratory are so convincing it has seemed well to include here a brief description of the technic of such a dissection (Fig. 2).

A transverse incision is made through the entire thickness of the superficial fascia on the ventral wall of the abdomen, from the median plane, to the anterior superior spine

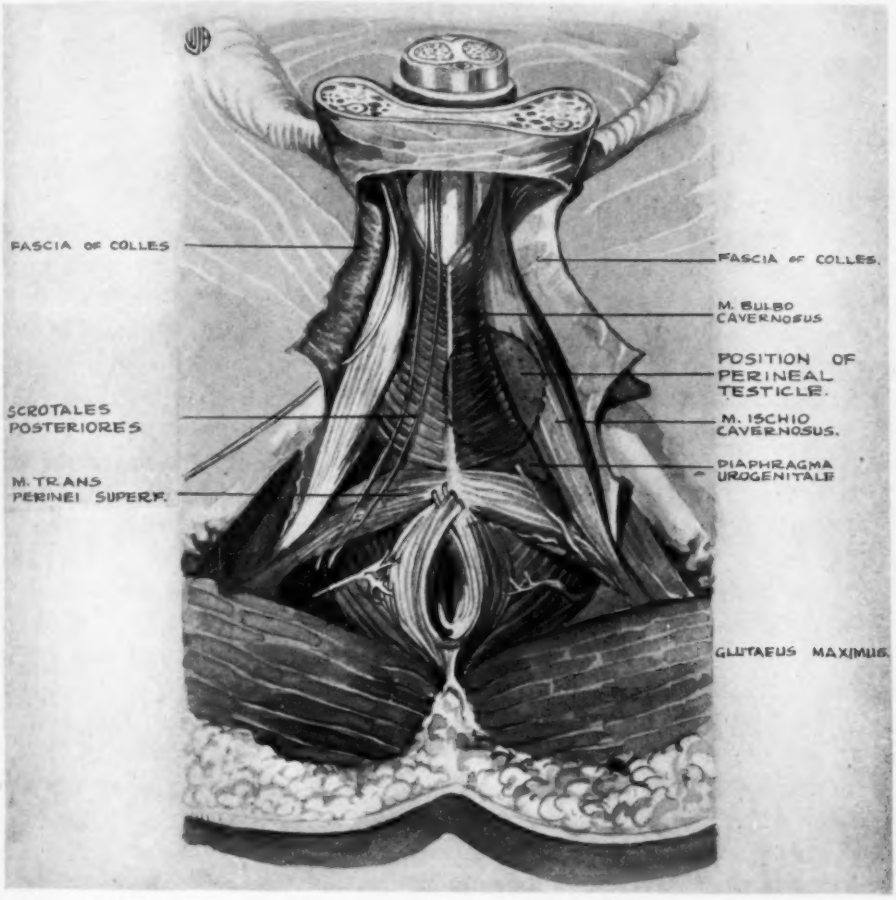

FIG. 2.—Diagrammatic representation of a dissection of the male perineum.

of the ilium. Upon raising the inferior edge of the divided fascia, the two layers of the superficial fascia can be easily distinguished. The fingers can then be insinuated between the fascia of Scarpa and the pearly looking tendon of the external oblique muscle and as they are pushed distally little resistance is encountered since the fascia of Scarpa is bound down to the aponeurosis of the external oblique muscle only by some lax areolar tissue. The fingers can readily be passed as far as the inguinal ligament and no further for there the passage of the hand into the thigh is barred by virtue of the fusion of the fascia of Scarpa with the fascia lata along the line of the inguinal ligament. If now the fingers are carried medially to the region of the pubes and then inclined distally it will be found that they can pass downward behind the fascia of Scarpa and along the spermatic cord into the perineum. No barrier apposes the passage of the hand in this direction and thus the continuity of the fascia of Scarpa and the fascia of Colles will have been demon-

strated. The fascia of Colles is spread over the urogenital diaphragm and has very definite attachments around the limits of that triangle. Thus, laterally it is fixed on either side to the rami of the ischia and pubes while posteriorly it is tucked around the two superficial transverse perineal muscles and blends with the base of the fascia of the urogenital diaphragm (triangular ligament). In this manner a pouch is formed which is of the utmost importance in this discussion. This is the superficial pouch of the perineum and certain important parts are placed within its boundaries, *i.e.*, the superficial muscles of the perineum, the bulb of the urethra, the crura of the penis, the perineal vessels and scrotal nerves, the long perineal branch of the posterior cutaneous nerve of the thigh and the termination of the pudendal artery.

This description of the connections of Scarpa's fascia and of Colles' fascia, of the continuity of one with the other, and of their relations to adjacent structures has a most important bearing upon the unusual positions which ectopic testes are prone to assume.

To digress for a moment, we may add that it also gives a very striking explanation of the course which would be taken by urine escaping from a rupture in the urethra distal to the urogenital diaphragm. The effused fluid flowing along the tissue planes under these circumstances makes its way upward into the scrotum over the penis and along the spermatic cords to the front of the abdomen, filling and distending the potential space between the fascia of Scarpa and the aponeurosis of the external oblique muscle. It cannot gravitate distally to the front of the thigh because there the fascia of Scarpa fuses with the fascia lata along the line of the inguinal ligament.

In an intra-uterine male fœtus at the eighth month of development the descent of the testis has so far advanced as to permit it to escape from the subcutaneous inguinal ring. The remainder of the journey which consists of an excursion over the crest of the pubes and into the depths of the testis sac, we have good reason to suppose is the most perilous part of the whole journey, for outside the inguinal ring the testis is deprived of the downward impulse of the contracting abdominal muscles and of the intra-abdominal changes of pressure which aided its passage through the inguinal canal. Here no passive force promotes the continued advance of the testis, but rather the sole responsibility for its progress rests upon the active contractile power of the chorda gubernaculi. In explanation of the occurrence of ectopic testes the writer has conceived that at this dramatic moment the chorda is insufficient and that as a result of the stress its fibres part at some point between its insertions. Should such an accident occur the testis would be left helplessly stranded between the external ring and the scrotal neck and would lie between the fascial planes that have just been discussed. That all such testes remain to be classified subsequently as pubic retentions or that they all shortly find their way into ectopic positions is not the case. Some, no doubt are retracted into the inguinal canal and remain to be classified as undescended testes, while it is possible that others may pass on into the testis sac.

It should be borne in mind that such an unguided testis is subsequently free to move to any point within the fascial planes in which it lies, limited only by the length of its spermatic cord. Mention has been made of the course

which may be taken by urine after a rupture of the urethra in front of the triangular ligament. One can readily see that a testis which has passed the subcutaneous inguinal ring in event it does not reach its normal place in the scrotal sac may assume any position in the interfascial planes followed by such extravasated urine limited only by the length of its spermatic cord. In other words, the aberrant testis will move along the tissue planes in the line of least resistance. Thus, one can identify the possible ectopic positions that are available to a testis which has lost its guide after it has escaped from the subcutaneous inguinal ring. It may incline proximally insinuating itself between the fascia of Scarpa and the aponeurosis of the external oblique muscle and come to rest in the neighborhood of the ring, in which case the condition is called *interstitial ectopic testis*. In event such a testis is accompanied by a patent processus vaginalis, there may be an associated interstitial hernia of the congenital variety. Such a testis cannot pass distally into the region of the thigh because of the fusion of the fascia of Scarpa with the fascia lata along the line of the inguinal ligament. Such a testis may pass medially to the region of the symphysis pubis and then incline distally, so that it comes to rest upon the dorsal surface of the penis at its base under its fascia, in which case the unusual condition is known as penile ectopic testis. In most cases, however, the testis makes its way over the pubic crest and on encountering some obstacle, such as an atresia at the scrotal neck, slips down over the deep surface of Colles' fascia into the superficial sac of the perineum. Here it finds a resting place among the structures already enumerated as being constituents of that sac. It may not pass beyond the most posterior limit of that sac which is marked by a transverse line drawn between the anterior parts of the ischial tuberosities in front of the anus. Thus, commonly perineal testes occupy a position in the perineum about 2.5 cm. anterior to the anus and just lateral to the median perineal raphé. It is conceivable that such a dislocated testis might be accompanied by a hernia of the congenital perineal type and Coley has reported such a case.

As for the entire group of congenital ectopic testis, there are four classical varieties, which in order of the frequency of their occurrence, are as follows: (1) perineal, (2) interstitial, (3) penile, (4) femoral. The last of these is an entity entirely distinct from the others and is extremely rare. It is commonly understood to be a result of an extremely long mesorchium as a consequence of which the testis instead of being brought up sharply to the internal abdominal ring is permitted to sag away from it to the region of the femoral ring, through which it subsequently herniates distally into the thigh, coming to rest in the femoral triangle in the region of the saphenous opening. Fauntleroy [4] reports such a case accompanied by a femoral hernia.

Of the three more common ectopias, *i.e.*, perineal, penile and interstitial, it is significant to note that a fascial pocket or sac is a striking part of the picture in the first two varieties and that fact alone causes one to be even more convinced that the aberrant testis did roll around between fascial planes until it accidentally became caught in a pocket.

It is not very uncommon at operation to find ectopic testes fixed at their lower poles to the adjacent tissues and such a fixation has no doubt influenced many to accept the theory of multiple gubernacular tails as being the etiological factor in their production. In the opinion of the writer, however, to interpret such an adhesion as a cause for the ectopic testis, is only another example of confusion between cause, on one hand, and effect, on the other. The primary cause of an ectopic testis is a breaking of the chorda at a crucial moment with the resultant dislocation of the testis. When the unguided testis comes to rest in its ectopic position the proximal end of its fractured chorda makes a new connection with adjacent tissues.

Congenital perineal testis is often accompanied by some abnormality of the corresponding vaginal process of peritoneum. No instance is known in which the vaginal process found its way into the scrotum while its testis went into the perineum. Since under normal conditions the vaginal process precedes the testis into the scrotum, it probably precedes the testis into its aberrant position in these abnormal cases. Ordinarily congenital perineal testes are found to possess the usual tunica vaginalis in a distorted form, but commonly the fusion of that part of the process vaginalis which extends from the abdominal inguinal ring to the tunica is lacking or incomplete, so that in the majority of cases there is a predisposition to inguinal hernia if a congenital hernia does not already exist.

McAdam Eccles,[3] in his work on the imperfectly descending testis, relates that among 936 instances of imperfect descent of the testis associated with hernia, only five were found to be of the perineal variety.

As for the functional capacity of congenital perineal testes, it may be said that during infancy and preceding the stage of puberty the testes, whatever their positions, have little influence upon the development or the general health of the individual. The converse is true, however, from the period of puberty onward, for at the beginning of this period the testes assume a dual rôle manifested by the formation of spermatozoa within the tubules (external secretion) and by the elaboration of hormones (internal secretion) within the confines of the intertubular interstitial tissue. The function of the former is that of procreation and the function of the latter in harmony with the internal secretory products of other glandular structures is that of participation in the development of secondary sexual characteristics.

The writer has not been able to find any record of a case of congenital perineal testis treated by orchidectomy which has been followed by histological study of the specimen. However, Odiorne and Simmons,[9] at the Massachusetts General Hospital and others, have studied specimens of undescended testes treated by orchidectomy, and what they found in their cases one might anticipate would be found in any specimen of ectopic testis.

The organs they studied as a rule were flaccid and small. Microscopically the tunica albuginea in each specimen examined was from two to five times the normal thickness.

It is most interesting to note that the so-called interstitial cells were present in all cases and were uncommonly abundant.

The epithelium of the tortuous seminiferous tubules and the membrane propria upon which they rest were found to deviate markedly from the normal.

In every case the basement membrane was found to be thickened; in some this thickening was slight, and in others so marked as to all but obliterate the lumen of the tubules. In every case also the epithelium itself was markedly abnormal. In those tubules in which a thickened basement membrane had nearly obliterated the lumen, there were no cells or only a few degenerated cells, which were irregular in shape. In other sites the tubules were lined with a single, rarely a double, layer of similar cells of large size, showing no mitoses. These latter cells probably represented supporting cells or the sustentacular cells of Sertoli. Cytogenic or spermatozoa-producing cells were rarely found. Spermatogonia and spermatocytes could be distinguished in some cases, but the processes had rarely gone on to completion and only in exceptional instances were tubules found containing perfectly formed spermatozoa. These changes are no doubt the result of injury and represent progressive chronic inflammatory alterations due to pressure. The cytogenic cells of the testis are highly specialized cells and the sustentacular and interstitial cells are progressively less highly specialized. It is a fundamental pathological rule that the various cell elements of the human organism vary in their power of resistance to injury and regeneration, inversely as the degree to which they are functionally specialized.

By virtue of the protected position and extreme freedom of movement of testes which are normally placed in the scrotal sac, they are rarely subjected to traumatic injury. Congenital perineal testes and ectopic testes generally are not possessed of such freedom of movement. Their positions are more or less fixed and they are subjected not only to the constant pressure of contracting muscles, but also in an exaggerated degree to the possibility of wounds and contusions. They are not immune to epididymitis and vaginal hydrocele, and malignant degeneration may develop.

The diagnosis of congenital perineal testes or of aberrant testes in any of the other usual sites is not commonly attended with any great difficulty. The history reveals the fact that one side of the scrotal sac has been unoccupied since birth and the chief complaint frequently is that of pain, which of a characteristic nature is definitely localized and usually is related to some form of exercise.

Upon physical examination the scrotal sac is found empty and atrophic on one side while the opposite side is occupied by a testis of normal size. In the absence of hernia the inguinal canals are negative. Palpation about the site where pain is complained of reveals a mass beneath the skin and superficial fascia corresponding in shape, consistency and roughly in size to the normal testicle. The possibility that this mass may be a new growth or the product of chronic inflammation must be ruled out. Pressure upon the mass elicits the characteristic testicular pain and it will be found to be more or

less mobile. With ordinary care the vas and constituents of the spermatic cord may often be made out.

The treatment of congenital perineal testis and of the other varieties of aberrant testes is extremely important. The kind of treatment varies according to the age of the subject and the presence or absence of some complicating factor such as hernia, new growth, hydrocele, torsion, the procedure in event of any one of which is only too obvious.

As has previously been stated during infancy and early childhood, irrespective of its position whether undescended or dislocated or normally situated, the testes exert little influence upon the development or general health of the individual, while with the beginning of adolescence the testis ceases to be afunctional. If a testicle is allowed to remain in an aberrant position during the period immediately preceding puberty there is sufficient reason to believe that it will not undergo properly the complete cycle of changes incident to adolescence. If it is allowed to remain in the aberrant position throughout the period of adolescence there is equally good cause to believe that it will remain cytogenically functionless permanently and that therefore the procreative possibilities of such a testis will be almost if not completely lost in most cases. On the other hand, it is believed that the endocrine power of such a testis is not impaired even when it is left permanently in its abnormal position. That this is the case is evident both by clinical observation and by the microscopic findings of Odiorne and Simmons which have been noted above. Therefore, it may be said that the secondary sex characteristics of the possessor of permanently displaced testes are uninfluenced. He is subject to the same desires and motives as the normal individual even though he be a double cryptorchid and sterile.

In view of these facts it becomes evident that measures to correct the position of aberrant testes should be undertaken. They should be brought into the scrotum and it is desirable that this be accomplished at as early a date as is consistent with certain factors which should be considered. Thus, in the absence of some complication it would not be wise to subject a child under ten years of age to the necessary surgical procedure. During infancy and early childhood there is a possibility that such a testis may find its way spontaneously into the scrotum. Such an occurrence is not very uncommon in cases of undescended testes. This is not the case, however, with congenitally dislocated testes. The latter, however, are frequently quite mobile and no doubt much could be done during infancy and early childhood by the exercise of gentle manual traction upon the testis in the direction of the scrotal neck. That such efforts on the part of mother or nurse under the direction of the surgeon might be accompanied by success is not impossible. If the child reaches the age of ten or twelve without the testis having come into the scrotum, an operation should be performed in order that the testis be properly placed in an ample time to permit of the normal prepubertal alterations. It would seem unquestionable that the finer adjustments of functional balance between the cytogenic and the endocrine elements of the testis and between

the endocrine elements of the testis and the coördinating endocrine elements elaborated by other hormone-producing glands will best be served by a properly timed operation. After puberty has been established the benefit that may be derived from orchidopexy decreases in direct relation to the length of the period between puberty and the operation.

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BONE REGENERATION FOLLOWING CHRONIC SUPPURATIVE OSTEITIS OF THE DISTAL PHALANX

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In order to demonstrate the end results in cases of chronic suppurative osteitis of the distal phalanx of the finger, the following investigation was undertaken at the Vanderbilt Clinic. We wished to show: (1) that the degree of bony regeneration following sequestration will vary directly with the amount of healthy bone and periosteum left in place; (2) that in cases in which spontaneous sequestration is allowed to take place, with resulting preservation of periosteum, a well-functioning, sightly phalanx may be expected; (3) that apparently unfavorable early X-ray findings do not necessarily indicate a poor prognosis, and (4) that extreme conservatism in the handling of the infected bone is the method of choice.

Fig. 1.—Case I. Showing loss of major portion of diaphysis.

The process in all cases was that of a chronic osteitis following acute infection of the distal anterior closed space. Treatment consisted in the institution and maintenance of adequate drainage of the closed space followed by removal of the sequestrum only when the latter had completely separated itself from adjoining healthy bone and periosteum. X-ray plates were taken at the time of sequestration, at intervals thereafter, and until, in our opinion, maximum regeneration had taken place.

CASE HISTORIES

Case I.—J. R. (V. C. 39995F) Age forty years. Anterior closed space infection followed by chronic osteitis of the distal phalanx. Spontaneous sequestration on the nineteenth day following bone involvement. Figure 1 shows separation of practically the entire dia-

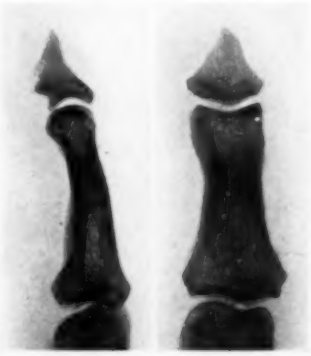

Fig. 2.—Case I. Showing bone regeneration, two months following sequestration.

physis. Figure 2 shows amount of regeneration after a period of two months. There was normal joint function and but slight flattening of the tip of the finger.

CASE II.—L. P. (V. C. 67417E) Age twenty-seven years. Infection of the anterior closed space with resulting osteitis of the distal phalanx. Sequestration on the twenty-first day. Figure 3 shows the bare epiphysis remaining. Figure 4, taken one year later, shows practically complete regeneration of the phalanx.

CASE III.—C. H. (V. C. 66425E) Age fifty-five years. In this case there was a similar

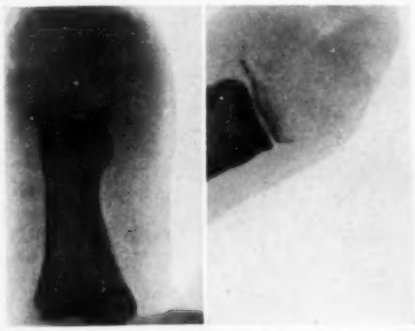

FIG. 3.—Case II. Shows loss of practically the entire diaphysis.

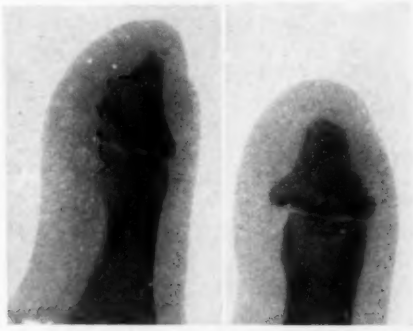

FIG. 4.—Case II. One year later, showing almost complete regeneration.

FIG. 5.—Case III. Shows destruction of distal two-thirds of the phalanx.

FIG. 6.—Case III. Shows complete regeneration nine months later.

type of infection. Sequestration on the twenty-third day. Figure 5 shows destruction of the distal two-thirds of the phalanx. Figure 6 taken nine months later, shows complete regeneration of bone. The irregularity on the anterior surface in each case evidently represents the point of emergence of the sequestrum.

In the foregoing cases we have demonstrated the results which may be looked for following what we have styled "the conservative treatment" of chronic suppurative osteitis of the distal phalanx. It only remains to caution against certain ill-advised practices, notably "bone scraping," curetting, and even amputation, all too frequently met with in the handling of this condition.

ERRORS IN THE X-RAY DIAGNOSIS OF OSTEOGENIC SARCOMA

REPORT OF TWO CASES WITH AUTOPSY FINDINGS

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The interest in and better understanding of tumors of bone should be greatly increased by the stimulus of "The Registry of Cases of Sarcoma of Long Bones" instituted by Codman.[1]

Accurate data will be obtained and classified for accumulative study in those recorded cases in which pathological material has been obtained at operation or autopsy for histological examination to correlate with the clinical findings, especially those of the X-ray.

That present diagnostic methods are not conclusive is strikingly shown by the approximate 50 per cent. error in diagnosis of supposed sarcomas of bone in the 454 cases submitted for registration.

The value of the X-ray findings in the diagnosis of bone lesions has been overemphasized. The X-ray is undoubtedly the most important single finding, except the histological picture of the pathological tissue itself, but must always be studied in relation to all other clinical data obtainable. The X-ray findings in any group of bone lesions are not specific.

In certain cases of osteogenic sarcoma the X-ray picture is so distinctive as to be accurately diagnostic. In others the X-ray findings may simulate those of pyogenic osteomyelitis so closely that a differential diagnosis between these two conditions is not possible from the plate alone. On the other hand, pyogenic and syphilitic osteomyelitis and carcinomatous metastases to bone may intimately resemble osteogenic sarcoma. The danger, therefore, in attempting to formulate hypotheses concerning treatment of osteogenic sarcoma from cases in which the diagnosis had been based in large measure upon the X-ray picture, should be evident.

Any form of treatment of patients suffering from proven osteogenic sarcoma is notoriously ineffectual. Amputation is still the chosen treatment of most surgeons for osteogenic sarcoma which involves one of the bones of the extremities and when there are no demonstrable metastases. Unfortunately in even the earliest and seemingly most favorable cases for cure by amputation, metastases to lung may have already taken place by the time operation is done, and the patient dies within a few months from the rapid growth of these metastases.

Before amputation is performed in a case of osteogenic sarcoma, X-ray examination should be made of the chest to detect, if possible, the presence of pulmonary involvement. Positive findings will necessarily contra-indicate

[1] Codman: The Registry of Cases of Bone Sarcoma, S. g. O., March, 1922, pp. 335-343.

amputation of the extremity. Negative findings, however, will not rule out the presence of pulmonary metastases, as the course of the disease following amputation so often shows.

If there is no evidence of metastases and amputation is decided upon, the latter should only be done after the diagnosis of osteogenic sarcoma has been substantiated by incision into the tumor. A constrictor should be placed proximal to the growth before the incision is made. The gross appearance of a malignant tumor of bone is usually unmistakable. It may be impossible to distinguish between a sarcoma, carcinomatous metastasis or an endothelioma, however, from the gross appearance of the exposed tumor. If there is any question in the surgeon's mind regarding the diagnosis on exposing the tumor, a piece of tissue should be removed for microscopical examination.

Of late years the X-ray and radium have been used in an increasing number of cases diagnosed as sarcoma of bone and some very satisfactory results have been reported. In cases which have been considered as cured, one may always question the diagnosis. The primary tumor in a case of undoubted bone sarcoma will sometimes respond to active X-ray therapy in a surprising manner. Experience may show that the results from this form of treatment are better than from the mutilating treatment by amputation.

In those cases in which the clinical diagnosis suggests osteogenic sarcoma and the primary growth is *inoperable* because of its location or local extent, the treatment should be X-ray or radium. In such a case an incision for diagnosis or for the removal of tissue for the microscope is inadvisable as a routine measure because not infrequently following this simple procedure, the tumor will be stimulated to very active local growth, and metastases may develop rapidly. Therefore in these cases which would be inoperable if they should prove to be osteogenic sarcoma, a better procedure is to institute X-ray or radium therapy.

The therapeutic value of this treatment should be apparent in a relatively short time. The growth of the tumor may be retarded or it may even begin to melt away. If nothing is being accomplished by the X-ray or radium, and if the diagnosis of osteogenic sarcoma is questioned, then incision may be made into the diseased tissue to allow of a positive diagnosis.

The following two cases are reported because they emphasize the difficulty which may be had in arriving at a diagnosis in any case of bone disease, because of conflicting evidence obtained in the history, general or local examination or laboratory findings. In each of these two patients the diagnosis was largely arrived at by the X-ray findings, the diagnosis seemed to be substantiated by the reaction of the bone lesion to X-ray therapy and each case came to autopsy for final study.

CASE I.—F. H., age seventeen. Admitted January 12, 1920 to the University Hospital.

Present Illness.—In the winter of 1918 the patient was confined to bed for about a week with the "Flu." In the summer of 1919 he had a mild pleurisy on the left side, became short of breath, felt tired and worn out. Later signs of fluid were found in the left chest and about a quart of straw-colored fluid was removed by needle. Two days

later two quarts of reddish-brown fluid was removed. He had a high fever for six weeks. Weight had been lost before aspiration of the chest, but he began to gain following that. He returned to work in September, 1919, and was feeling fairly well. About November 15, 1919, he began to have soreness in the left shoulder. Movement of the shoulder became painful especially when lifting. Later he noticed some swelling in the shoulder and tenderness on pressure. There has been no grating sensation and no redness. No other joints involved. Has been having some cough and raising some sputum. He is not losing weight or strength. Denies any injury to the shoulder. He was admitted to the University Hospital two months after the shoulder began to pain. *Family History.*—Negative. *Past Medical History.*—Negative.

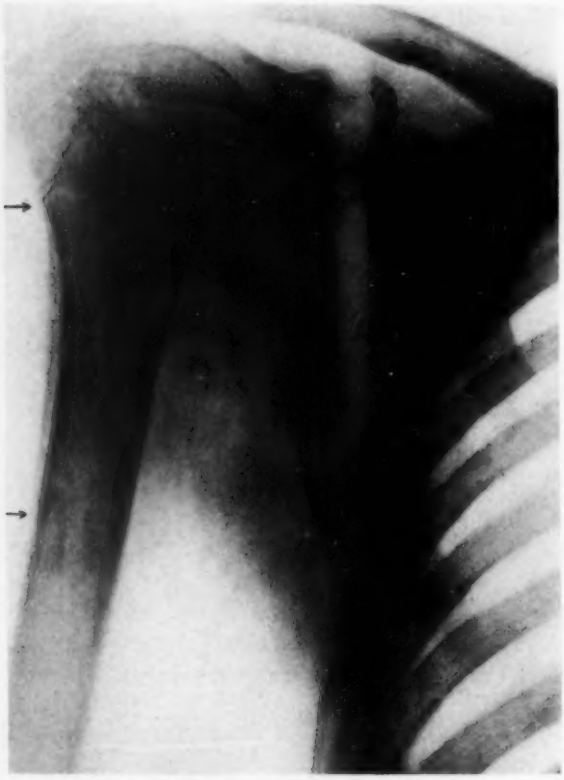

FIG. 1.—Case I. X-ray finding of the humerus which led to the diagnosis of osteogenic sarcoma.

Examination.—Slightly built boy, with a flushed face. Chest expansion somewhat restricted on the left. Percussion shows some dullness in the lower left axilla. A few crepitant râles are heard in the left apex.

Left Shoulder.—Moderate swelling over the deltoid region and in the axilla. No redness. All movements of the shoulder are markedly restricted because of pain. *Tenderness is very marked* over the upper third of the humerus and in the shoulder joint, so that satisfactory palpation of the humerus is not possible. Superficial veins are enlarged over the shoulder. In the axilla high up one obtains a sense of resistance as if from a growth.

Blood.—Hæmoglobin 88 per cent., white blood cells 9600, Wassermann negative.

X-ray.—Left shoulder region. There is a spindle-shaped swelling of the upper third of the shaft of the humerus involving the lateral aspect especially. This is due to bone proliferation from the periosteum. The cortex and medullary portion of the humerus seems normal. The joint outline is entirely normal. The impression is obtained from the X-ray picture of osteogenic sarcoma of periosteal origin. Von Pirquet reaction is positive.

Aspiration under gas anæsthesia. "Needle introduced into left wall of the chest failed to bring anything, as did the needle introduced into the humerus externally, but a needle introduced into the swelling of the axilla obtained a large amount of blood which led to a diagnosis of sarcoma." Microscopic examination of the clotted blood was negative for tumor cells.

Course.—During the first week of entrance the patient had a fever ranging between 101–103 and a pulse of 110 average. He was treated intensively by Dr. Bundy Allen with the X-ray and was given increasing doses of Coley's toxin. He had a febrile reaction with the injections but the general febrile course was progressively downward so that it ranged

around 99–100. Was discharged March 13, 1920 with the following note: "Motion in the shoulder was definitely improved by X-ray treatments and use of Coley's toxin. There was also marked decrease in the amount of pain. Slight noticeable decrease occurred in the size of the mass in the axilla."

During the following year he was given three more courses of X-ray treatment, the first of these being accompanied by injections of Coley's toxins. At each admittance the boy showed marked improvement in every way. The fever was gone after the first course of X-ray and Coley's toxins, he increased in weight and strength and he felt well. The swelling in the shoulder region and axilla began to decrease in size and the range of motion increased progressively. At the end of nine months the shoulder was of the same size as the opposite and the pain and tenderness were gone. There was still an indefinite sense of resistance high up in the axilla. X-ray pictures of the humerus showed no evidence of bone pathology whatever.

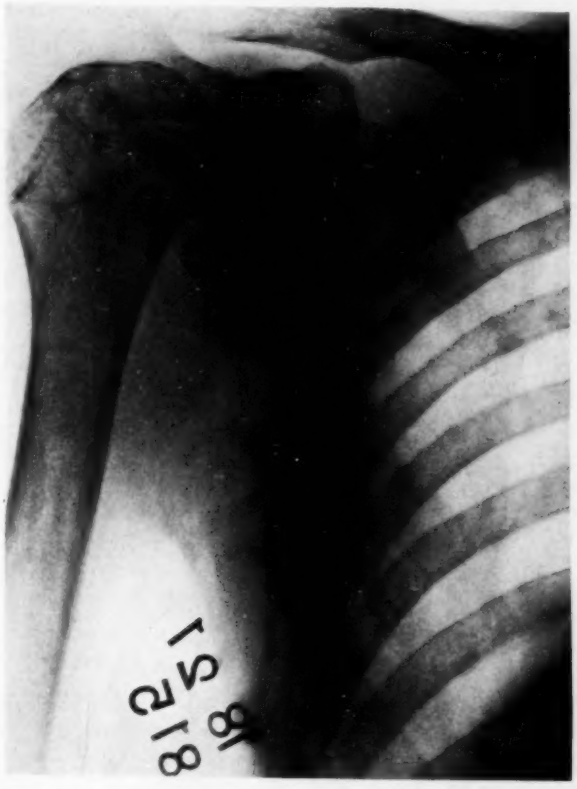

FIG. 2.—CASE I. After one year of X-ray therapy and Coley's toxins, all active symptoms were gone.

Seventeen months following his initial entrance to the hospital he began to cough and have night sweats. He began to have a fever as high as 102° every afternoon. The shoulder continued to improve. Examination showed slight lagging of the left chest and crepitant râles could be heard over it. X-ray plates of the chest showed both lungs to be extensively mottled by gross shadows and a diagnosis of sarcomatous metastases to the lungs was made.

The cough continued, dry and hacking in character. One morning after a severe paroxysm a cupfull of blood was raised. A moderate number of acid fast bacilli were found in smears of the sputum. This finding was made again two days later. It was felt that the metastatic process in the lung had lighted up a latent tuberculous focus. The patient soon began to lose ground rapidly and died in December, 1922, two years after the onset of the symptoms referable to the shoulder for which he had entered the hospital. A partial autopsy was allowed in the patient's home.

Autopsy Findings.—An incision was made over the upper end of the left humerus and carried onto the chest wall to the sternum and over the latter, downward to the xiphoid. The upper one-half of the humerus, the shoulder joint and the axilla were exposed.

There was a moderate amount of fibrous connective tissue in the axilla and the muscles of the arm and around the joint seemed somewhat atrophic. The humerus showed no evidence of tumor or infection. It appeared perfectly normal in every way. The shoulder joint was intact. There was no evidence of any joint lesion. No tumor mass, nor enlarged lymph-nodes were found in the axilla.

Both pleural cavities were obliterated by adhesions. Both lungs were extensively involved by areas of consolidation. In some of these areas, caseation had taken place and in others, cavities the size of walnuts were present. The gross picture was that of extensive progressive pulmonary tuberculosis. No areas suggestive of tumor metastases were found. No further examination of the body was permitted.

Histological examination of the bone showed no evidence of any pathological process whatever. Sections of the lung demonstrated the lesions of tuberculosis only. No evidence was found of tumor.

Discussion.—The history and physical findings in the chest were strongly suggestive of pulmonary tuberculosis and the condition in the shoulder at first was felt to be a tuberculous arthritis.

FIG. 3.—Case I. X-ray of the humerus removed at autopsy.

The local physical findings could be those of either tuberculosis of the joint or sarcoma of the humerus, although the indefinite mass high in the axilla which gave only blood on aspiration pointed strongly to sarcoma.

The X-rays showed no pathology in the joint, but a proliferative lesion of the upper end of the humerus involving the periosteum. The picture was strikingly that of an osteogenic sarcoma.

The reaction of the lesion to X-ray therapy was spectacular. No form of immobilization was used. The symptoms of intolerable pain and severe tenderness began to show early relief, the swelling subsided, the fever fell and X-ray pictures of the humerus demonstrated that the periosteal new bone was melting away.

The development of gross changes in the lung suggesting metastases seemed to clinch the diagnosis of osteogenic sarcoma. The later finding of tubercle bacilli in the sputum was disturbing, however.

It is impossible to state in the light of the autopsy findings, just what the bone pathology was which produced the marked symptoms. There may have been an osteogenic sarcoma of the humerus which went on to a two-year cure under X-ray therapy aided by Coley's toxins. It is more likely that the lesion was an unusual one of tuberculosis, stimulating the periosteum to bone production.

If this patient had not died and an autopsy been held, this would have been considered an undoubted case of osteogenic sarcoma cured by X-ray therapy.

CASE II.—D. N., age fourteen. Admitted March 8, 1920 to the University Hospital.

Present Illness.—Patient was last perfectly well in September, 1919. During this month she felt dumpish and her legs ached when she sat down. Appetite poor. In November, her first menstrual period occurred, but this caused no change in the symptoms.

In December, she sat down hard upon the ice and the small of the back was sore between the hips. In January, patient developed constant pain in the left thigh anteriorly and in the left knee. The knee was swollen and it hurt the patient to move the leg. She was in bed a week, and was then able to get up a little for two weeks. Sharp shooting pains developed in the left groin; she went to bed and has stayed there ever since. Slight movement of the lower extremity causes severe pain relative to the groin and knee; also complains of a knot in the ankle. The thigh is very tender to the touch but has never been discolored and she thinks has never been swollen. It feels hot. She has no pain if she lies perfectly quiet. Has lost much weight and one-half of her strength. Has had chiropractic and osteopathic treatments without relief. Enters the hospital two months following the onset of symptoms.

FIG. 4.—Case II. X-ray evidence which largely contributed to the diagnosis of osteogenic sarcoma.

Past Medical History.—Respiratory system: Does not catch cold easily nor have a chronic cough. Raises no sputum and never coughed up blood. Genito-urinary system: Admits some trouble in starting and stopping the stream recently, otherwise the history is negative.

Family History.—One paternal aunt had a tuberculous kidney removed. Absolutely negative otherwise.

Social History.—Menses began four months ago, has had two periods since. Admits of some leucorrhœa.

Examination.—The patient is an undernourished girl who is extremely fearful of being examined because of pain in the left lower extremity.

Lungs.—There is a higher pitched percussion note over the left apex in front. The breath sounds are harsh over this area. Subcrepitant râles are heard over the left clavicle.

Abdomen.—There is diffuse tenderness over the lower half of the abdomen.

Extremities.—The left limb is held everted, abducted and flexed. The leg is flexed on the thigh. There is marked pain on movement referred to the hip. The entire left extremity seems larger than the right. There is marked bony tenderness throughout the left thigh. Palpation causes marked tenderness over both hip joint and knee. There is definite thickening or induration in the region of the hip joint. The joint fluid in the knee seems a little increased but the bones do not seem enlarged. There is no pitting on pressure over the shin.

The lymph glands are nowhere enlarged.

Blood—Wassermann negative. Hæmoglobin 100 per cent. Leucocytes 16,032.

Differential count: Polymorphonuclears 70 per cent., lymphocytes 29 per cent., transitionals 1 per cent.

X-ray.—The X-ray of the hip reveals a marked picture of osteoporosis.

The upper end of the femur seems separate from the neck. The great trochanter is absorbed and the lesser trochanter barely visible. The upper end of the shaft is moth eaten and there is no outline of the capsule of the joint. There is no bony overgrowth.

Aspiration of the region of the left hip in various places under gas anæsthesia obtained no blood, fluid nor material of any sort.

Urine.—Albumen was found on occasions, but no casts. Red cells were present on two examinations. Bence-Jones bodies were present. An acid fast organism was found in one uncatheterized specimen, but none in urine drawn from bladder, and guinea-pig inoculation of the urine was negative for tuberculosis.

FIG. 5.—Case II. After six months of X-ray therapy. Note the marked increase in density of the bone and the filling in of the eroded areas. The patient was practically free from any active symptoms at this time.

Fever.—On the second day following admittance the patient had a fever of 101°. Following this the temperature stayed around normal with occasional rise to 99°–100°.

Course.—X-ray treatments were begun by Dr. Bundy Allen March 13, and carried out intensively through March, April, May, July, October and December.

The patient improved definitely as far as the local and general conditions were concerned as shown by symptoms and X-ray pictures.

The pain began to subside with the beginning of X-ray therapy and in three weeks the patient could be turned in bed or moved onto a cart to be taken to the X-ray room with very little discomfort. The tenderness became markedly less. This general improvement was progressive.

At the end of a month, X-ray plates seemed to show an increased density of the pathological bone and a decrease in the amount of destruction. This also was a progressive improvement.

The local and general improvement became such that pain and tenderness in the region of the hip became completely absent after six months. Some induration persisted, and there was very little if any movement in the hip joint. The patient was up daily in a wheel chair.

About December 21 an ulcer through the skin developed over the groin, and increased in size. It was considered to be an X-ray burn. January 4, 1921 a violent hemorrhage took place through this ulcer and the patient died within a half hour.

Autopsy by Doctor Armstrong.—On the left groin was an ulcerated area roughly circular in shape and about 6 or 7 cms. in diameter. The ulcer was necrotic. The borders were ragged and necrotic but not undermined or terraced. In the floor of the ulcer and exposed by it was the femoral ring and the femoral sheath. The sheath and the walls of the blood-vessels were soft and easily torn.

The body was opened by the usual midline incision. The heart and pericardium showed no pathological change of note. The left pleural cavity was free from fluid but contained a few firm adhesions about the apex and the posterior surface. The left lung was without other notable pathological changes. The right pleural cavity was free from fluid and exudate but there were many firm adhesions on the posterior surface. In the upper lobe was an area about 4 cms. in diameter which had the appearance of a partially healed tuberculosis. The mediastinal glands were large and some of them caseated.

The abdominal organs were without gross pathological changes of interest. There was no free fluid, no adhesions and no enlarged glands. The kidneys were normal in size and position. The capsule stripped readily and the cortex of the kidneys appeared normal.

A deep incision was made from the anterior superior spine of the ileum downward along the external surface of the thigh for a distance of 25 cms. As the incision was made a large amount of thick creamy pus escaped. It was this pus that burrowed down between the muscle sheath of the anterior and lateral muscles of the thigh to within a few centimetres of the knee. Within the muscle sheaths were found many small abscesses and burrowing sinuses filled with this thick creamy material. The head of the femur was broken off with the fingers, being honey-combed and soft, transparent, jelly-like substance. The head, neck and upper portion of the femur was so soft and honey-combed that it was easily broken. There was grossly no suggestion of neoplastic growth.

Microscopically.—Sections from the upper lobe of the lung showed the characteristic lesions of tuberculosis. The mediastinal glands were also tuberculous. A tubercle was found to involve the capsule of the spleen. The kidneys showed no pathology.

The bone presented a large amount of old granulation tissue infiltrated with lymphocytes, plasma cells and polymorphonuclear leucocytes. One section shows small pieces of necrotic bone lying in the centre of miliary abcesses. Around these pieces of necrotic bone there are masses of cocci. There is on evidence of tuberculosis in any of these sections. No evidence of tumor is found.

Discussion.—Differential diagnosis had to be made in this case between tuberculous osteomyelitis of the femur, pyogenic osteomyelitis and osteogenic sarcoma.

The positive lung findings, the presence of acid-fast bacilli in the urine, although this was not substantiated in catheterized specimens, and the history of tuberculosis in an aunt, suggested strongly tuberculosis. The local condition was also strongly suggestive of tuberculosis in the history of its onset and the physical findings. The relatively afebrile course spoke against an active tuberculous joint condition. The X-ray picture was not characteristic of a tuberculous hip disease, because of the extent of the pathological process involving particularly the bone from the head to the shaft, the latter in the region of the trochanters being markedly disintegrated.

A subacute pyogenic infection of the femur had to be considered principally because of the X-ray findings. However, in spite of the local evidence

of an active destructive process of the bone of considerable extent, no abscess in the soft tissues could be made out and pus was not found by aspiration. Also, the absence of a sustained febrile reaction pointed against an active pyogenic infection, although there was a leucocytosis of over 16,000. The striking symptomatic and pathological response to X-ray therapy was not to be expected of a pyogenic bone infection.

An osteogenic sarcoma was the presumptive diagnosis and was made in large measure by exclusion. This diagnosis seemed to be confirmed by the early relief obtained from X-ray therapy. No other form of treatment was used. The severe pain on movement and the very marked tenderness began to disappear within a few weeks until the girl was changed from a patient who was fearful and fretful into one who was bright and happy and able to wheel herself in comfort around the ward. The swelling and induration in the region of the hip subsided and the X-ray seemed to demonstrate a beginning healing of the pathological process in the bone.

The autopsy revealed no gross nor microscopic evidence of neoplasm. An area of pulmonary tuberculosis was found but the bone involvement was not tuberculous. The post-mortem findings were those of a pyogenic osteomyelitis of the femur. It is possible that the pyogenic infection of the bone took place from without through the X-ray ulcer which developed two weeks before death, and was superimposed upon some other pathological process which was healed through the action of X-ray therapy. The most likely explanation is that the original bone involvement was a low-grade pyogenic osteomyelitis, hæmatogenous in origin, which began to subside about the time the patient entered the hospital. In all probability the X-ray therapy had little or nothing to do with the improvement of this patient. We have seen no positive benefit from the use of X-ray in other proven cases of pyogenic osteomyelitis.

If this patient had gone on to complete recovery, or if an autopsy had not been obtained, the positive diagnosis of osteogenic sarcoma would have been apparently established and the X-ray would have been credited with a therapeutic result which would be unwarranted in relation to osteogenic sarcoma.

SACRAL NERVE BLOCK ANÆSTHESIA

THE ANATOMY INVOLVED, TECHNIC, AND CLINICAL APPLICATION

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Nerve blocking is rapidly becoming a valuable adjunct to the expert surgeon. It is now generally recognized that local or regional anæsthesia not only may be a life-saving measure in the surgical treatment of old and debilitated patients, but that it is a method that may be successfully employed routinely in a number of major surgical operations. It not only may reduce the mortality in emergency operations, but it lowers the morbidity in the general routine of surgical procedures. Local anæsthesia, however, is not of like value for surgical work in all regions of the body. Its value depends on the limitation of the operative field and the ease of access to the nerve trunk supplying this field. In operations involving the pelvic floor and viscera the operative field is definitely limited by the bony pelvic girdle, an area entirely supplied by sacral nerves. Consequently blocking of the sacral nerves within the sacrum is an easy and efficient means of producing local anæsthesia. In the opinion of surgeons who have had the most experience with the method, it has only to become better known to be more extensively employed.

Notwithstanding the fact that the popularity of sacral nerve block anæsthesia in operations on the pelvic floor and viscera has increased considerably during recent years, marked differences of opinion still exist as to the limitations and efficiency of the method. This is well illustrated by the remarks in Oxford Surgery of two eminent American authorities. In the section on local anæsthesia, Harris asserts that blocking of the sacral nerves by an intrasacral injection is one of the most satisfactory procedures in the field of local anæsthesia. In the section on spinal anæsthesia, Babcock asserts that sacral anæsthesia (also called epidural, extradural and caudal anæsthesia) is efficient in only 55 per cent. of cases, and that it has such limitations that only very devoted enthusiasts will have the patience to continue its use. Braun has never favored the method. In the fifth edition of his text-book (1919) he foregoes any discussion of the method because "spinal and sacral anæsthesia are opposed to local anæsthesia." In his sixth edition the method is discussed in the chapter on spinal anæsthesia with but very little enthusiasm.

It is difficult to understand why eminent authorities on local anæsthesia should classify sacral nerve block with spinal anæsthesia. Whether sacral nerves are blocked by the parasacral, the single epidural-injection, or the transsacral method, the procedure is essentially different from spinal anæsthesia and should not be confused with it. The nerves in the sacral canal

are identical with nerve trunks in other parts of the body, and in reaching them with anæsthetic solutions within the sacral canal, and at their exits through the sacral foramina, they are affected the same as other nerve trunks would be by paraneural injections. In spinal anæsthesia the injection is made into the dural sac, confined within it at all times, and distributed by the spinal fluid. In sacral nerve block by the single epidural injection, the fluid may ascend the vertebral canal in the extradural space when a large amount is injected, and it also escapes through the sacral foramina in all directions, but with proper technic it never penetrates the dura to mingle with the spinal fluid. Sacral nerve block by the transsacral, or by the single epidural-injection method, should therefore be no more confused with spinal anæsthesia than block of these nerves by the parasacral method, which is credited to Braun.

The efficiency of sacral nerve block anæsthesia by the epidural-injection method varies greatly in the hands of different operators. The highest incidence of failures, 45 per cent., is recorded by Babcock, although he reports no series of cases. Pickens reports seventeen failures in 100 cases. The best results were obtained by one of us (Scholl), who in a series of 400 urologic cases had only twenty-seven failures (6.7 per cent.). The incidence of failures may be further reduced by proper combination with the transsacral method described later. Meeker and Frazer, in a series of 225 operations on the pelvic floor and viscera at the Mayo Clinic, report only three failures by the combined method.

To obtain perfect anæsthesia constantly by block of the sacral nerves, as by block of other nerve trunks, one must have a thorough knowledge of the anatomy of the region. This is much more important in regional than in infiltration anæsthesia, and involves not only descriptive, but topographic or perspective anatomy. To block nerves successfully one must not only know their distribution, but be able to visualize the course of their trunks in relation to surrounding structures, especially to the bony prominences of the skeleton, which are the most reliable landmarks on the living subject. It requires practice in passing the needle into the sacral canal and foramina, always to deposit the solution next to the nerve trunks; when anæsthesia does not result, it is because the solution has not been accurately placed.

Early in our experience with sacral nerve block anæsthesia, we became interested in the topographic anatomy of the sacral region, particularly that of the posterior aspect of the bony pelvis. A perusal of the literature on this subject emphasizes the frequency of variation in structure of the sacrum. This variation is impressed more forcibly by a comparative study of sacrums from the adult skeleton. We have recently studied 100 such sacrums from the anatomic laboratories of the University of Chicago, Loyola University, and Hahnemann Medical College of Chicago, observing anatomic anomalies and taking accurate measurements of each sacrum.* Valuable information

* The authors wish to express their thanks to Dr. R. R. Bensley, of the University of Chicago, Dr. R. M. Strong, of Loyola University, and Dr. W. B. Smith of Hahnemann Medical College, for affording them the use of the osteologic collections.

has thus been obtained as to the influence of these structural variations and malformations on the technic of blocking sacral nerves.

The Normal Sacrum.—As regards block of sacral nerves the most important anatomic features of the sacrum are the canal, its contents and the topography of the posterior aspect of the sacrum (Fig. 1). The sacral canal is a continuation of the spinal canal and is enclosed by the bony walls of the sacrum, except at its lower end where it terminates in the hiatus sacralis. The canal in cross-section has the shape of an isosceles triangle above, with base anteriorly, average dimensions being 31 mm. for the base, and 16 mm. for the altitude. The canal becomes smaller below as the forward curvature of the sacrum is followed. It contains the dural sac, which usually ends at the lower border of the second sacral segment, usually about 6 cm. from the sacral hiatus. Thompson, in an examination of thirty-three cadavers, found the average distance to be 5.8 cm., the shortest 4 cm., and the longest 7 cm. Within the dural sac the nerves of the cauda equina are bathed in spinal fluid. As each pair of nerve roots of the cauda equina passes outward, the nerves lie free for a variable distance in tubular prolongations of the dura before the latter blends with, and contributes to, the thickness of their sheaths. The nerves here lie against the anterior wall of the sacrum and when they reach the lateral foramina the contribution of the dura to the perineural sheath is no longer evident.

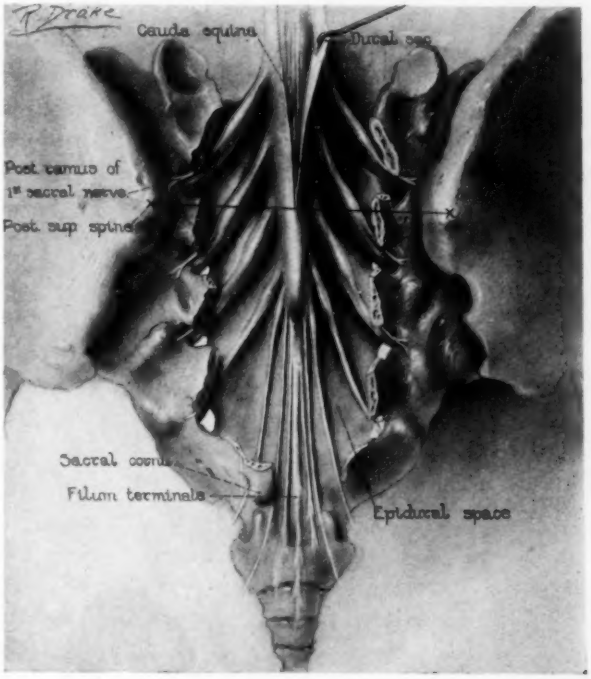

FIG. 1.—Anatomy of the epidural space. Sacral laminæ have been entirely removed. The fatty areolar tissue and lymphatic and venous plexuses normally filling up this space have also been removed, leaving the dura and nerve trunks in position. Note the relation of the interspinous line *a*, to the first and second sacral foramina.

Within the dural sac the nerves of the cauda equina are bathed in spinal fluid. As each pair of nerve roots of the cauda equina passes outward, the nerves lie free for a variable distance in tubular prolongations of the dura before the latter blends with, and contributes to, the thickness of their sheaths. The nerves here lie against the anterior wall of the sacrum and when they reach the lateral foramina the contribution of the dura to the perineural sheath is no longer evident.

Within the sacrum the dura is not attached to the periosteum as in some other localities, except by a downward continuation, the filum terminale at the lower end of the sacrum. The space between the dura and the periosteal lining of the canal is called the epidural cavity (cavum epidurale) and is filled with delicate, fat, areolar connective tissue, lymphatics and venous plexuses.

The lower end of the sacrum presents a triangular opening on its posterior aspect, the hiatus sacralis giving entrance to the sacral canal. The extremities

of the base of this triangle are marked by the two sacral cornua, which represent an undeveloped fifth spinous process. The apex of this triangle is designated by the termination of the sacral crest (crista sacralis). Usually the fourth pair of arches have not united at this point, but the posterior bony wall is continuous between them (Fig. 2, e). The average distance between sacral cornua is 13 mm., the height of the hiatus 22 mm., and the distance between anterior and posterior walls at the apex of the triangle 4.5 mm. The hiatus is covered over by a dense ligamentous structure, the posterior sacrococcygeal ligament, or obturator membrane.

The four lateral sacral foramina lie between sacral segments and give passage to the upper four pairs of sacral nerves. The fifth sacral nerve passes through the sacral hiatus laterally below the sacral cornu and lies in the sacral notch below the fifth segment. These foramina lie in the same straight line on either side of the sacral crest, are oval or circular in shape, and covered over by ligamentous structures. They traverse the sacrum anteroposteriorly and almost perpendicularly to the tangent of the sacrum. They are very nearly equidistant from each other, the distance decreasing from above downward. The average distance from S-1 to S-2 is 17 mm.; from S-2 to S-3, 14 mm.; from S-3 to S-4, 14 mm., and from S-4 to the sacral notch at the lower margin of the sacrum, 13 mm. The average longitudinal diameter of the first, second, third and fourth sacral foramina are 26, 19, 12 and 7 mm., respectively.

Variations in Structure.—Variations in structure which are of significance in the technic of sacral nerve block are those involving (1) the amount of closure of the sacral arches to form the sacral crest, (2) the number of sacral vertebræ, (3) the number and size of foramina, (4) the curvature of the sacrum, and (5) traumatic and pathologic deformities, or asymmetric sacrums.

The size of the sacral hiatus varies greatly, according to the degree of closure of the posterior arches of the sacral segments during the developmental period (Fig. 2). In our series of sacrums it was large enough in all cases to permit the passage of a small spinal puncture needle, although in two or three instances it would have been exceedingly difficult in the living subject because of anteroposterior flattening. The hiatus may occasionally be reduced in size by osseous bars passing from sacral to coccygeal cornua, in cases of partial ossification of sacrum and coccyx. The cornua in such instances, however, are distinctly palpable.

Operators have also ascribed failure to enter the sacral canal to the presence of an ossified sacrococcygeal ligament, thus entirely closing the sacral hiatus. We have found no evidence of osseous changes in this membrane in sacrums and are inclined to explain a large percentage of such failures on the basis of improper technic.

The laminæ of the last sacral segment never join, and those of the fourth often do not. In sixteen instances the hiatus extended up to the third spine, in eight up to the second, and in one to the first, while in one there was an

entire deficiency of the roof of the sacral canal, or complete sacra bifida (Fig. 2). Wheeler, in the examination of 1000 röntgenograms of the sacral area, found eight complete sacral bifida.

Deficiency in the roof of the sacrum above the sacral hiatus is rare. It occurred between the first and second segments in three instances, between

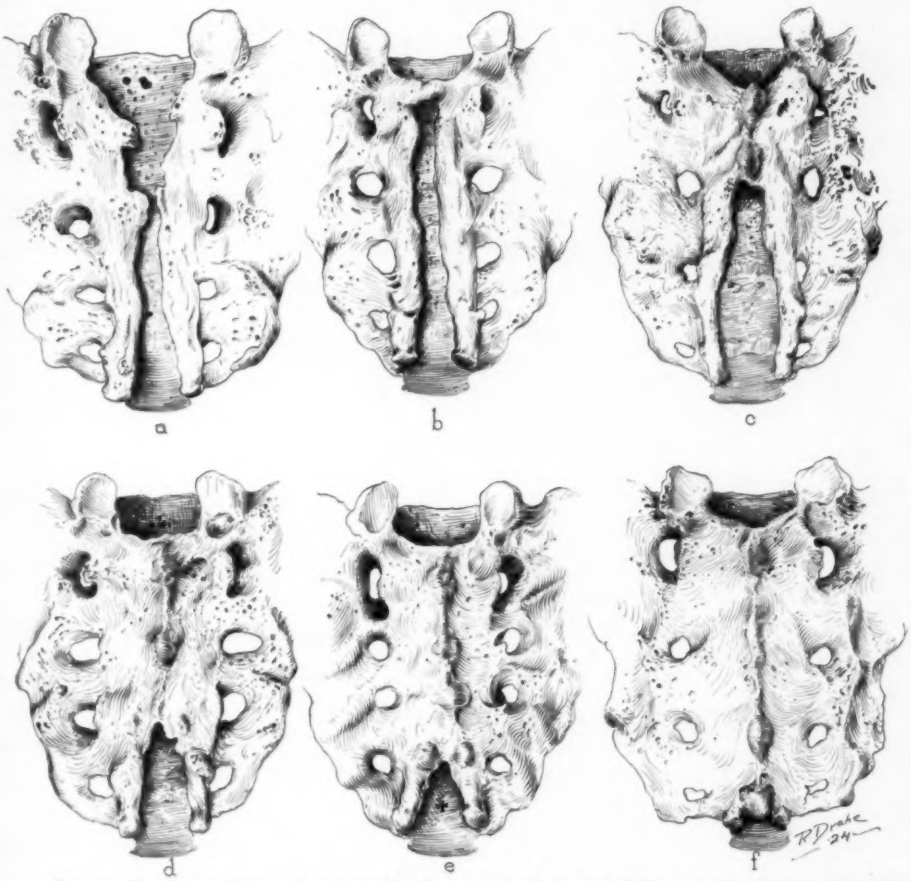

FIG. 2.—Specimens illustrating the variable amount of closure of the sacral arches to form the sacral canal and sacral hiatus. *a*, complete sacral bifida, the canal being open throughout its entire extent. *b*, closure of the first arch only. *c*, closure of the first two arches. *d*, closure of the first two arches, the bony wall extending down to the third arch, spines of which have not united. *e*, the normal condition. The first three arches are formed, the bony posterior wall extending down to the fourth arch, spines of which have not united. The cross marks the site of puncture for the caudal injection. *f*, abnormally low closure and small hiatus. A definite overhanging fourth spine is present.

the second and third segments, and between the third and the fourth in one instance each (Fig. 3).

There is frequent variation in the number of vertebræ composing the sacrum; not infrequently there are six, a condition more often due to inclusion of the first coccygeal than of the last lumbar vertebra. Vesalius depicts the sacrum as consisting of six pieces. In our series, sacrums of six segments were found in 19 per cent. of the cases. In a collected series of 2476 sacrums, Frets found them in 20.76 per cent. of the cases. Sacrums of four segments

are much rarer, only one such specimen being encountered in our series (Fig. 4). Adolphi found only one in 292 sacrums, and Fischel but one in 306 instances. An increase in the number of segments is therefore much more common than a decrease.

The number of sacral foramina varies with the number of segments. In sacrums of six segments there are five foramina on each side, and in sacrums of four segments, three. The longitudinal diameter of the first sacral foramen is much greater than the transverse because of the projection of a bony lingula from the medial posterior margin of the foramen. The other foramina are more nearly circular in shape. They decrease in longitudinal diameter

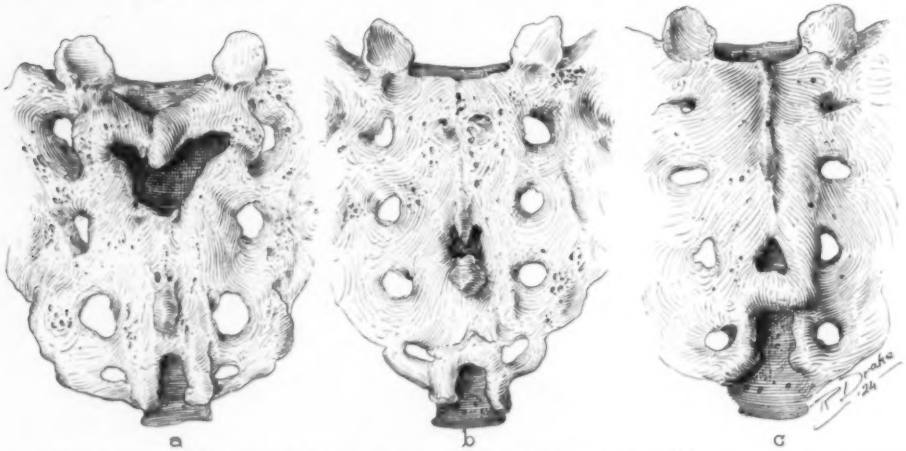

FIG. 3.—Abnormal openings in the posterior sacral wall above the sacral hiatus. *a*, opening between the first and second arches; *b*, between the second and third, and *c*, between the third and fourth. Puncture of the dura would be possible through these openings.

from above downward, the average diameters in our series being: S-1, 10.8 mm.; S-2, 8.3 mm.; S-3, 7.4 mm., and S-4, 6.2 mm. The average distance from the median line to the median edge of the first foramen is 21 mm., and that of the fourth foramen, 15 mm.

Considerable variation was noted in the size of foramina in the different specimens (Fig. 4). Their size does not depend on the size of the sacrum, as is well illustrated by a comparison of the two specimens of the same size, *c* and *d* in Fig. 6. The diameters of *c* were: S-1, 14 mm.; S-2, 12 mm.; S-3, 10 mm., and S-4, 7 mm., while those of *d* were 6, 4, 3, and 1 mm., respectively.

Asymmetry of foramina was not observed, although in certain cases of lumbosacral vertebræ, there were no perfect foramina on the lumbar side, but this is of no significance in the technic of nerve block. Foramina were patent and easily accessible to the needle except in two instances. In these, the right fourth foramen was covered over by a bony bridge (Fig. 4, *d*), which, while not completely closing the foramen, was sufficient to prevent the insertion of a needle passed perpendicularly.

The sacral curve is not, as a rule, equal and uniform in either sex. It is generally flattened above, and has a more pronounced curve below the third

segment. The absolute depth of the curve is greater in men than women. Also in man the sacrum is more likely to be flattened above, and curved in the lower portion. The depth of the curvature varied from 4 to 44 mm. in

FIG. 4.—Variations in number of sacral segments (*a* and *b*), and size of foramina (*c* and *d*). *a*, is a four segment sacrum, present in less than 1 per cent. of cases; *b*, represents a six segment sacrum present in 20 per cent. of cases; *c* and *d* are sacrums of approximately equal size, the foramina of *c* being roughly three times the size of those of *d*. A bony bridge over the right fourth foramen of *d* entirely obscures it.

Peterson's series. In rare cases the sacrum may be convex, particularly in the rachitic pelvis. One such sacrum was encountered in our series (Fig. 5, *a*), while fifteen were almost straight, conforming more to the type, Figure 5, *b;* seventy-nine conformed more to the normal (Fig. 5, *c*), while in seven instances the curvature was greater than normal (Fig. 5, *d*). In the most

marked concavities, the curvature is more pronounced in the lower segments, tending toward a hook-shape, flattened above, and markedly rounded below; when the sacral hiatus is small, the needle can be advanced but a very short distance in the sacral canal.

Asymmetric sacrums are either of traumatic or pathologic origin. There were no such specimens in our series. We have seen twelve patients, however, in whom the canal could not be entered. One was a boy, aged seven years, with congenital deformity of the sacrum and external genitalia. The other was a man, aged sixty years, with an extremely small sacrum, in which neither the caudal nor the lateral foramina could be found. In five cases there was a history of injury and also much palpable deformity. The remaining cases were among the first attempted and were probably due to faulty technic. In most of them satisfactory anæsthesia was produced by injection of the lateral foramina as far as possible, and infiltration of the coccygeal region.

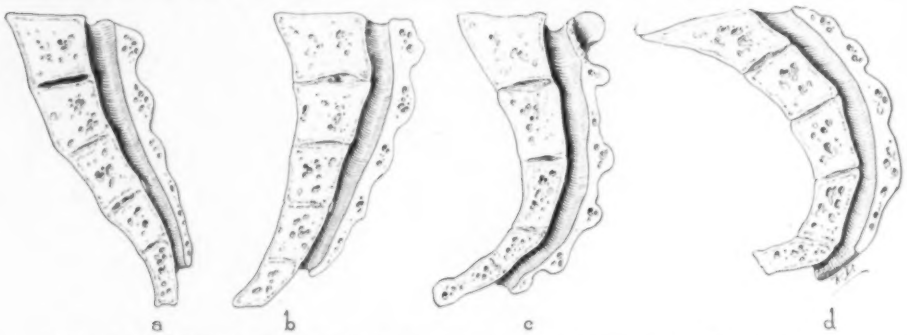

FIG. 5.—Variations in curvature of the sacrum. *a*, a rare instance of slightly convex curvature, probably the result of rickets (1 per cent.); *b*, slightly concave, less than the usual amount of curvature (15 per cent.); *c*, the normal curvature (79 per cent.), and *d*, greater curvature than normal, especially in the lower half (7 per cent.).

Fractures of the sacrum are rare. The lower end is the portion usually involved, together with the coccyx, so that the resulting deformity is more likely to interfere with the injection of the hiatus than the lateral foramina. In rare instances healed fractures of the pelvis involving the sacrum may present distorted anatomic relations, but since only 0.8 per cent. of all fractures involve the pelvis, and since accompanying internal injuries are usually so severe as to lead to the death of the patient, sacral fractures are only rarely a complicating condition in anæsthesia of the sacral nerves.

Bony outgrowths, tumor formations and healed caries of the sacrum produce atypical deformities. These conditions are also very rare, and present themselves for perineal operations so seldom that they need offer no problem in the technic of sacral nerve block.

Sacral Topography.—Several methods of surface marking for the location of the sacral hiatus and foramina have been proposed. Several surgeons recommend inserting a finger into the rectum, grasping the coccyx and moving it to and fro while palpating for the sacrococcygeal articulation. This manœuvre is of little actual value. Besides the decreased asepsis of the

finger, there is the limited motion of the coccyx and the impossibility of recognizing this joint in obese patients. Moreover, the coccyx, particularly the first coccygeal segment, is often completely ossified to the sacrum. Location of the hiatus by this means is usually due more to the identification of sacral cornua by palpation than to the sacrococcygeal joint by manipulation of the coccyx.

As a result of anatomic studies, Lynch recommends that a line be passed from the posterosuperior spine to the opposite sacrococcygeal articulation, and the same on the opposite side, the point of bisection of these lines giving the location of the sacral hiatus. He does not state how the sacrococcygeal articulation is located, which of itself quite definitely determines the location of the sacral hiatus.

The most accurate surface anatomy is that calculated from palpable bony prominences. In the lower sacral region the cornua are the most prominent lateral tubercles, and are almost always definitely palpable, even in obese persons. With the index finger of the left hand the tip of the coccyx is palpated in the anal groove. The finger then follows the smooth posterior surface of the coccyx upward until the two sacral cornua are felt, one on either side. Somewhat higher in the median line the lower margin of the sacral crest may be identified, indicating the apex of the triangular sacral hiatus. This is the method of identification originally proposed by Cathelin.

The lateral foramina lie in straight lines on either side of the sacral crest. All authorities select a point just lateral to the sacral cornu for the lower extremity of the surface line, designating these foramina. Danis selects a point 3 cm. lateral to the fifth lumbar spine for the other extremity of the lateral sacral line. Pauchet joins the most prominent points of the iliac crests to form an interiliac line, which usually passes over the fourth lumbar spine. He then selects a point on this line 4 cm. lateral for the upper extremity of a lateral sacral line. Labat selects a point 1 cm. medial to the posterosuperior iliac spine for the designation of the lateral sacral line. In our experience the posterosuperior iliac spines are the most readily accessible bony prominences of the sacral region. Moreover, they bear a more constant relationship to the lateral foramina, and may be defined with greater precision than either iliac crests or lumbar spines. They lie within the sterile field and are considerably closer to the sacral foramina than either lumbar spines or iliac crests, so that any system of sacral topography with iliac spines as the basis must be correspondingly more accurate.

We measured the distance between the most prominent points of the posterosuperior iliac spines in 100 patients, and found the average to be 95 mm. (Fig. 6). We also measured the distance of sacral foramina from the median line in the series of sacrums. In the average adult the lateral sacral line passes through a point 25 mm. medial to the most prominent point of the posterosuperior spine. This spine in lean persons can be seen at once without palpation and is more prominent in men than in women. In the more obese women, in whom Michaelis' rhomboid is well marked, the spines are at

the lateral angles of this rhomboid, since the upper and lower sides are formed by the transverse and sacrospinalis, and the gluteus muscles, respectively.

Position.—Cathelin made the epidural injection with the patient lying on his left side with back arched and knees drawn up. This position has been followed by the Germans. Danis employed the ventral prone position for transsacral nerve block, which has proved to be much more accurate also for the epidural injection. Besides being more comfortable for the patient, the superficial landmarks may be taken with greater accuracy. In the lateral position the sacrum is displaced upward, while overlying soft tissues by their own weight hang lower in relation to the bony framework. The fall of the buttocks thus displaces the gluteal cleft at least 1 cm. lower than the sacral hiatus. In the ventral position, on the other hand, the sacral crest is always in the median line with respect to overlying soft tissues, and sacral cornua are equal distances from it. Placing a cushion under the hips raises the sacral region and thus accentuates bony landmarks.

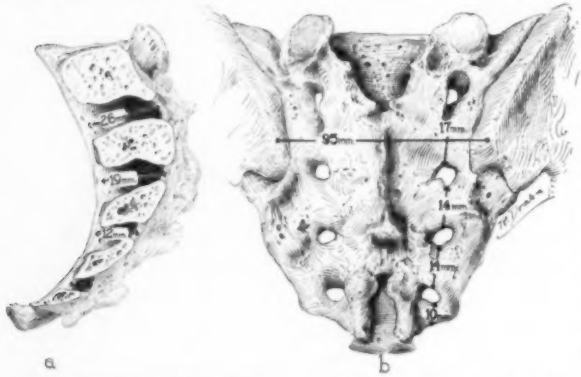

FIG. 6.—Dimensions of the average adult sacrum. *a*, the average anteroposterior thickness at the different foramina; *b*, distances between foramina and the relation of the interspinous line to the first and second sacral foramina.

Instruments.—As in any other surgical procedure satisfactory results cannot be obtained with unsuitable instruments, and many of the outfits advertised for use in local anæsthesia are entirely unsuitable. All that is required is the proper supply of needles and a syringe. Self-filling syringes and pneumatic injectors are of no value.

The needles are of much greater importance than the syringe, in block of the sacral nerves. They should be as fine as their stability will permit, thus minimizing the pain and trauma caused by their frequent passage through the soft tissues. There should be an adequate assortment of different lengths, and they should be made of good quality of steel so that a sharp cutting edge is maintained.

The needle used for puncture of the sacral canal is a spinal puncture needle of small calibre and made of a material which will bend but not break. There is danger of breaking a brittle steel needle within the sacrum because of the curvature of the sacral canal.

We have found the Labat syringe and needles very satisfactory in sacral nerve block. Owing to the extreme scarcity of the market supply and excessive price of the Labat outfit, Sharp and Smith have manufactured a syringe and needles according to Meeker's specifications, which we have found entirely satisfactory. The syringe is of 10 c.c. capacity and equipped with rings for

the hand grasp so that one may aspirate, or refill the syringe with one hand. It has an eccentric tip and is provided with a bayonet lock attachment which fastens the needle on. The needles are of an excellent quality of flexible steel,

FIG. 7.—Outfit for the induction of local anæsthesia. The glass barrel syringe is equipped with metal mounting and plunger. The tip is eccentrically located and equipped with a bayonet lock attachment. Rings for the thumb and fingers permit aspiration and refilling of the syringe with one hand. The needles are equipped with protecting sheaths and fasten onto the syringe by a locking device.

small in calibre and of different lengths to suit the different anæsthetic procedures (Fig. 7).

Technic.—The cutaneous surface over the sacrum is sterilized the same as in other surgical procedures and the same aseptic precautions followed. The sacral cornua are identified, and with the finest needle a dermal wheal is placed above a line connecting the cornua and in the median line of the body. This wheal marks the centre of the sacral hiatus. The underlying subcutaneous tissues and sacrococcygeal ligament are then infiltrated so that the passage of the larger needle will not cause pain. A spinal puncture needle of small calibre is used in making the sacral puncture (Fig. 9). This should

always be sufficiently small and sharp so that it will never be necessary to incise the skin with a tenotome for the insertion of a coarse spinal trocar. The needle is introduced through the anæsthetized skin over the hiatus, with bevel upward, and forming an angle of between 20° and 30° to the skin surface.[26, 27, 28, 42, 43] There is a sensation of increased resistance as the sacrococcygeal ligament is reached, and a definite snap is felt as the needle pierces the ligament and impinges on the bone of the anterior sacral wall. Whenever the needle is felt to pierce a dense membrane, pass through a free space, then come in contact with bone, there is no doubt but that the sacral canal has been entered. The needle is then withdrawn very slightly and depressed 20 to 30 farther until it is in a position approximately parallel to the sacral canal, when it is advanced gently and slowly 4 or 5 cm. into the canal, along the median line of the body. It usually passes readily but may strike either the anterior or posterior wall of the canal a short distance inside. If it strikes the anterior wall, depressing the shoulder, or using the finger as a fulcrum placed on the needle 1 cm. from the skin surface, and elevating the hub, will also elevate the point into the centre of the canal. When the needle impinges on the posterior wall, pressure applied on the sacrococcygeal membrane at the site of juncture usually releases it. If these devices are unsuccessful the needle should be withdrawn and re-introduced a little higher.

It is obvious that the ease of sacral puncture will depend on the size of the hiatus and the curvature of the lower sacrum. The easiest cases are those in which there is a partial sacral bifida, which allows the needle to be inserted higher than usual. If the ununited fourth or third sacral arches are not palpable in these cases, patency of the hiatus may be determined by perforating the occluding membrane with the small needle during the preliminary infiltration of tissues overlying the hiatus. The hiatus is small when there is a fourth sacral spine, and especially when it is flattened anteroposteriorly. Thompson, in an examination of thirty-three sacrums, found the canal accessible to the needle in all cases except in one cadaver in which the canal was markedly curved and unusually narrow and flattened. In cases of small hiatus associated with marked curvature, it is probably best to perforate the sacrococcygeal membrane with a small needle for infiltration, depending considerably on muscular sense for the proper insertion of the needle. This low sacral injection can then be associated with transsacral block for surgical anæsthesia.

Harris was unable to find an opening into the canal in two patients having a history of injury to the sacral region in early adult life. We have encountered four such patients with marked deformity and considerable bony overgrowth. In three instances in which the Kraske posterior resection of the rectum had been performed with removal of the coccyx and fifth sacral segment, no difficulty was experienced in puncture.

Accidents.—When too much force is used in inserting the needle or when the patient makes a sudden movement after correct insertion of the needle, the shaft may be broken. Cathelin reports two instances of broken needles

in 1000 injections: one needle broken at the entrance to the canal was readily removed; the fragments of the second were removed from the body of the fourth sacral vertebra at necropsy six months later. It had not caused any trouble. Harris, Pickens, and Lynch have reported instances of sacral insertions in which the needles were broken. In our experience, an assistant made a satisfactory sacral puncture and during injection the patient jumped suddenly, breaking the needle inside of the sacrum. It was necessary to remove the posterior wall of the sacrum before the fragment could be recovered.

Injection of Solution.—After correct insertion of the needle the stylet is withdrawn and the injection begun. When the needle lies correctly, the solution is injected almost without resistance. If considerable force is necessary the point of the needle may be buried beneath the periosteum and should be readjusted. If on injection a subcutaneous swelling appears, the needle has not entered the sacrum, but lies posteriorly in the subcutaneous tissues. This is the most common mistake in sacral puncture.

The solution should be injected very slowly and gently. About half of the total quantity is injected without moving the needle. Withdrawal is begun as the injection progresses, until at the conclusion the needle point lies just inside of the sacrococcygeal ligament. During injection the patient may complain of cramps in the legs, which is proof of correct insertion of the needle and usually indicates too rapid injection. The injection is always painless when not made too fast. In a slow injection the solution diffuses gradually through the tissues of the canal, whereas a rapid injection may cause a collection of solution at the point of the needle, tearing the delicate vascular network of the canal, and resulting in hemorrhage. Läwen advises two minutes for the actual injection of the fluid.

Proper precautions should be observed in order that intradural or intravenous injection will not result. In the average patient the needle is not advanced high enough for puncture of the dura, but in those with partial sacral bifida, in which the needle is inserted higher than usual, and in females, this accident may occur. Zweifel reports a death caused by the injection of 0.8 gm. of novocain into the dural sac. On the appearance of spinal fluid the needle was withdrawn, but insufficiently, death occurring ten minutes later from paralysis of the heart and lungs. Goldenburg mentions a case in which the full dose was injected into the dural sac without causing trouble, save a complete anæsthesia of the lower half of the body for forty-eight hours. Collapse has also been observed, probably from injection into the blood stream. Kronig reports a case of partial respiratory paralysis which he ascribes to injection into a sacral vein.

In order to prevent such disasters one should watch closely for the appearance of blood or spinal fluid as soon as the stylet is withdrawn. As injury to veins may occur without the appearance of blood, aspiration should be practiced with a half-filled glass-barrel syringe before beginning the injection. If either blood or spinal fluid appears, the needle should be withdrawn until aspiration is negative before beginning the injection. Changing the position

of the pelvis we regard as of little value, and we have never seen blood flow from the needle in spurts, as has Schlimpert. We have made dural puncture through the sacral canal four times. In one case, that of a man, the dural sac was entered 1 cm. from the sacral hiatus. The needle was withdrawn slightly until spinal fluid could not be withdrawn with the syringe and the injection then made successfully. In a small woman, spinal fluid was obtained when the needle was 2.5 cm. inside the sacral canal, the dural sac extending abnormally low.

Amount and Strength of Solution.—The quantity and percentage strength of the novocain solution varies in the hands of different operators. Läwen, who first demonstrated the practicability of the method for operative work, recommends from 20 to 25 c.c. of a 2 per cent. solution of novocain and epinephrin with the addition of sodium chlorid and sodium bicarbonate. He also employs from 25 to 35 c.c. of a 1.5 per cent. solution of novocain bicarbonate. Other formulas have also been proposed. Strauss adds sodium sulphate. Harris maintains that the efficiency of the solution is increased by the addition of calcium chlorid, and potassium sulphate has been employed for the same purpose. Bicarbonate of soda, sulphate calcium chlorid, and a number of other drugs were employed in combination with novocain in more than 500 cases in this series in an endeavor to increase the efficiency of the anæsthesia. Our experience has not indicated that the combination of other salts with the novocain results in a more satisfactory anæsthesia.

Time and Extent of Anæsthesia.—The anæsthetic effect is more rapid, the nearer the nerve trunk lies to the bulk of the fluid injected, and it varies according to the size of the nerve trunk. In the average case anæsthesia appears first in the anococcygeal area in about four minutes. It radiates from this point, and in ten minutes covers the posterior surface of the scrotum and penis. It spreads laterally down the inner surfaces of the thighs about 10 to 12 cm. Posteriorly there is complete relaxation of the sphincter ani with an area of anæsthesia covering the sacrum and buttocks. The anterior urethra is anæsthetized in from ten to twelve minutes. The meatus and internal sphincters are generally the last to become anæsthetized. In most cases the intensity of the anæsthesia gradually increases, reaching its maximum in from twenty to twenty-five minutes.

The distribution of anæsthesia is variable, especially the height, depending on the size of the sacral canal, the amount of solution injected, and the anatomic arrangement of the sacral contents. In the average case the greatest intensity of anæsthesia is manifested from the second sacral nerve downward. There are occasional instances of light anæsthesia in which the fourth and fifth, or the fifth sacral nerves are the only ones blocked. In many cases, however, the anæsthesia extends beyond these limits as high as the upper lumbar and lower dorsal nerves. Schlimpert and Schneider produced a high sacral anæsthesia sufficient for abdominopelvic operations. They injected large amounts of novocain, and employed deep preliminary hypodermic narcosis. This has proved to be a dangerous method, as toxic manifestations are often

quite severe. Wiedkopf's collected list of fourteen fatalities, for which local anæsthesia probably was responsible, included nine cases of high sacral anæsthesia. The present tendency, therefore, is to limit the epidural injection to the region of the sacral nerves.

There is considerable difference of opinion as to the influence of gravity on the spread of the injected solution. In high sacral anæsthesia the sacral region was elevated, the patient assuming the knee-chest position so that the solution would ascend to a higher level. The sitting posture has been employed by some so that gravity would keep the solution low in the sacral canal. In the lateral position it has been observed that anæsthesia occasionally is more marked and ascends to a higher level on the side on which the patient lies. While gravity may sometimes exert a slight influence, we believe that the solution diffuses through the tissues of the sacral canal more because of capillary attraction, and is usually little influenced by position. When the anæsthesia is higher on one side, it usually means that most of the injection has been made on that side of the sacral canal. We have observed a case of right-sided anæsthesia in a patient injected in the left lateral position. In two cadavers injected by Perrill, the fluid was confined to one side of the epidural space because thin fibrous bands formed a partial septum in the epidural cavity. In cases of complete failure of sacral anæsthesia, when the injection has been correctly made, it is logical to assume that there are such planes of cleavage which may localize the anæsthetic medium to one area.

In making the injection the sacral hiatus or caudal opening is located in the usual manner, the patient lying on his abdomen with hips elevated. In the majority of cases, an ampule, put out by Metz, containing 1 gm. of novocain in 5 c.c. of sterile distilled water, is used. Approximately 95 c.c. of sterile distilled water is brought to a boil in a sterile beaker, removed from the alcohol flame, and the contents of the ampule added. The mixture is allowed to cool, and 6 drops of a 1 : 1000 epinephrin solution added. The needle is inserted from 3 to 4 cm. into the sacral canal and from 50 to 75 c.c. of the mixture injected very slowly, allowing from six to ten minutes for the entire injection.

The chief disadvantage of caudal anæsthesia is its failure in a certain percentage of cases, particularly in the more extensive operations on the perineal and anal structures. While the proportion of failures varies according to the accuracy with which the technic is performed, the method, because of anatomic variations, is accompanied by a certain incidence of failure, even in the hands of the expert. The anæsthetic, because of the curvature of the sacrum, is deposited nearer the posterior wall, while the anterior divisions of the nerve trunks lie contiguous with the anterior wall. Moreover, the nerve trunks are exposed to the action of the anæsthetic solution more laterally where they are not protected by dural sheaths. The solution must thus diffuse through the contents of the epidural space before physiologic block of the nerve trunks will be effected. Even when successful, the height of anæsthesia is variable, extending from the anal margin in light anæsthesia to complete motor paralysis of the legs in extreme cases. However, if one is ready to

supplement the sacral injection by local infiltration when required, failure to induce a satisfactory surgical anæsthesia will be rare.

Other disadvantages are the delay after injection before the appearance of full anæsthesia, fifteen to twenty minutes being required, and occasional toxic manifestations. Consequently, we have limited sacral anæsthesia, mainly to the superficial operations on the perineum and terminal rectum, to urologic examinations, and to obstetrics. It is the method of choice for cystoscopy and painful proctoscopy.

Transsacral Nerve Block.—Block of the sacral nerves by the transsacral method, in the opinion of many operators, has overcome many of the incon-

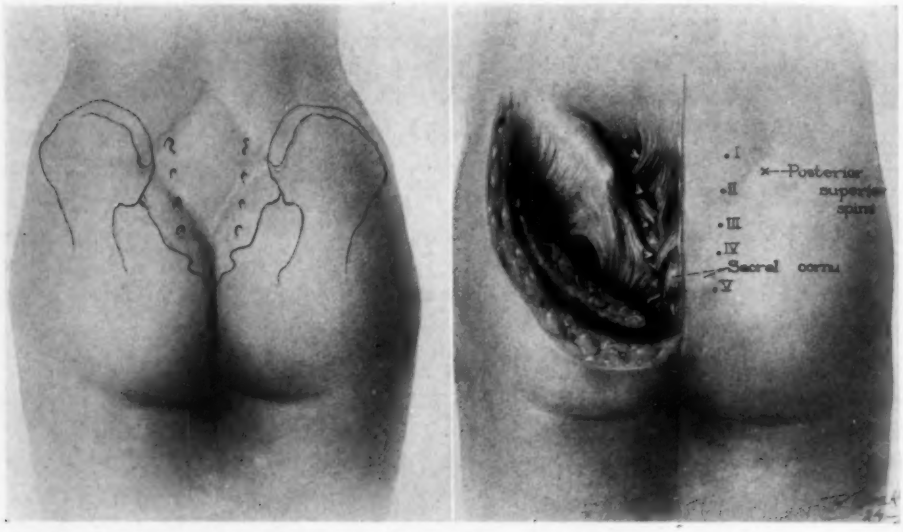

FIG. 8.—Topographic anatomy of the sacral region. The female figure to the left shows the rhomboid of Michaelis, and the relation of the posterior superior spines to the lateral angles of this rhomboid. On the male figure to the right is shown the relation of cutaneous points over the foramina to posterior superior spines and sacral cornua.

veniences and disadvantages of the sacral and parasacral methods. We find that the best results are obtained by the use of a very low epidural injection for anæsthesia of the fifth sacral and the coccygeal nerves, and transsacral block of the upper four sacral nerves. This technic gives a uniformly satisfactory surgical anæsthesia of a definitely limited height.

Technic of Transsacral Method.—With the patient in the same position as for the caudal injection, the lateral foramina are injected. The posterosuperior spine is identified, and a dermal wheal placed 2.5 cm. inward and 1 cm. downward, which in the average case marks the second sacral foramen. Another wheal is placed just lateral and below the sacral cornu which represents the sacral notch or fifth sacral foramen. The distance between is divided into three equal parts by two more wheals, thus defining the third and fourth foramina. The first is then located by a wheal placed 2.5 cm. above that which marks the second foramen, following the same straight line (Fig. 8).

The thickness of the soft tissues overlying the sacrum is much greater

above and less below, which necessitates the employment of needles of different lengths in searching for the various foramina. Less discomfort is given the patient when the smallest needle possible is employed in searching for a given foramen. Usually an 8-cm. needle is used in perforating the skin over the second sacral foramen. It is inclined somewhat downward and slightly inward until it is thought to be perpendicular to the tangent of the sacrum at that point. It is then gently advanced until it either comes in contact with bone or passes through the foramen. If it comes in contact with bone it is gently withdrawn and another search for the foramen made. In this way the distance from the periosteum to the skin is estimated, and when, after repeated attempts, the needle seems to perforate a membrane, advances farther than before and still does not encounter bony resistance, it has passed into the foramen. It is unusual to insert the needle directly into the foramen at the first attempt. If this should occur, it would probably be better to withdraw the needle, direct it somewhat more obliquely, and locate the margin of the bone more superficially, thus verifying the correctness of the first position. The needle may then be re-inserted in the original position.

The needle in the foramen is usually left in place to serve as a guide while search is made for the third foramen. A 5-cm. needle is employed for the next two lower foramina. After injection of the third and fourth foramina, the 10-cm. needle is inserted into the first sacral foramen. This foramen lies deepest of all, and prolonged search is often necessary to locate it. In order that the needle may advance perpendicularly to the plane of the sacrum, it must be inclined more toward the surface of the skin than in the other foramina. The foramina of the opposite side are next injected in the same manner. When both sides have been injected, the skin over the coccyx is tested for anæsthesia with a clamp. If it is insensible to pain the fifth sacral foramina are not injected; otherwise, they are injected in the manner described.

After a little experience, six-segment sacrums may often be recognized by the increased distance from the cornua to the posterosuperior iliac spines. In such cases the second sacral foramen is nearer the interspinous line, so that often it is best to search first for the third or fourth foramen before marking the others with dermal wheals. Having located one foramen, the needle is left in place and foramina above and below are located, using the first as the starting point.

Faulty technic may be rapidly improved by a study of the human skeleton and practice on a cadaver. It is important to remember the greater thickness of the overlying tissues near the base of the sacrum. If the needle is to be advanced perpendicularly to the tangent of the sacrum at any given point, there will be the greatest obliquity to the surface of the skin in searching for the first foramen, less for the second, and scarcely any at all for the lower three foramina. Lateral inclination of the needle should be guarded against, as after osseous contact the needle may be directed more laterally and pass entirely off from the sacrum.

The needles should be introduced a greater distance into the upper than into the lower foramina. It is best to make the injection anterior to the median point of the foramen, moving the needle somewhat to and fro. Our measurements of the thickness of the sacrum at the different foramina indicate that inserting the needle 2, 1.5, 1, and 0.5 cm. into the sacrum in injecting the first, second, third, and fourth foramina, respectively, would be most accurate.

Quantity of Solution.—The amount and strength of the solution employed varies with the size and resistance of the patient. For greatly debilitated patients and for relatively poor surgical risks, a solution of 0.5 per cent. strength is used, the amount being gauged more or less by the probable size of the sacrum. From 20 to 40 c.c. of the solution is injected into the sacral canal, then the sacral foramina are injected according to their size and the size of the nerve trunk to be blocked. The greatest amount should thus be injected into the first foramen, and the quantity for each successive foramen reduced by 1 c.c.: that is, 7, 6, 5, 4, and 3 c.c., respectively. From 75 to 140 c.c. of the 0.5 per cent. solution has given uniformly complete anæsthesia. When a 1 per cent. solution is employed, as is usual in robust persons, from 20 to 25 c.c. is injected into the sacral canal and the posterior foramina in the same ratio as with the 0.5 per cent. solution. From 60 to 100 c.c. of a 1 per cent. solution has in all cases produced complete physiologic block. Ten drops of epinephrin are always added to each 100 c.c. of solution.

Proper precautions must be observed in the preliminary preparation of the patient and in the search for the foramina so that the procedure will not be too painful. The proper preliminary narcosis of morphin and scopolamin should be given when needed, the amount being determined by the patient's age, weight, and general resistance. The dose should be sufficient to allay apprehension, but not to produce a state of somnolence or twilight sleep. In many weak, debilitated, and bedridden patients, and particularly in the aged, no preliminary narcosis is necessary. For the average adult, morphin ⅙ gr., and scopolamin 1/200 gr. are given an hour before operation. Often, if patients are robust and of more than average weight, the dose must be repeated from one-half to one hour after the first administration.

The greatest pain in searching for foramina is caused by making the dermal wheals, but it is transitory and usually well tolerated. In highly sensitive patients, ethyl chlorid has been recommended to anæsthetize the skin for the entrance of the needle, but we have found this to be unnecessary. While making the initial prick with the fine needle the thumb should be on the plunger, so that at the moment the needle enters the skin the solution can be injected instantly. In this way the puncture may sometimes be made without the patient's knowledge. If the needles are sharp and bright there is no further pain unless the periosteum is roughly probed, which besides causing pain, bends the sharp point of the needle to a hook so that it tears the tissues when withdrawn and requires more force for penetration. Such needles should be discarded at once. Pain may occasionally be produced by

advancing the needle directly into a nerve trunk. The pain is sharp and lancinating, and is radiated through the pelvis to the genitalia or down the legs according to the nerve trunk reached. When this occurs the needle should be withdrawn from 1 to 2 mm. so that a perineural, and not an endoneural, injection will be made. An endoneural injection of a large nerve trunk with the same amount of solution required for block by diffusion of this solution after perineural injection is more likely to injure the nerve trunk and result in post-anæsthetic pain.

Therapeutic Application.—While Cathelin is usually given credit for suggesting the feasibility of sacral anæsthesia, his epidural injections were for the purpose of medication of the sacral nerves. He employed these injections in the treatment of sciatica, lumbago, the painful crises of tabes dorsalis, enuresis, and sexual neuroses. As the result of his experiences in more than 1000 injections, he regarded it as a valuable therapeutic measure in pathologic conditions involving the sacral nerves.

The most common therapeutic use of epidural injections in the Clinic is in the treatment of sciatica. Ott reports results in a series of forty-eight cases in which the sciatica pain was not due to diabetes, caudal tumor, or other causes of so-called sciatica. Repeated epidural injections, with the removal of possible foci of infection in a large percentage, resulted in permanent cure in 29 per cent., and in permanent amelioration of symptoms so that the patient was able to continue his occupation with a fair degree of comfort in 37 per cent. In the remaining 34 per cent. no permanent beneficial results were obtained.

These injections also seem to have a certain definite value in the treatment of intractable pruritis ani and vulvæ. Smiley reports thirteen cases of anal and genital mixed pruritis relieved by this means, in eight of which other medical and surgical measures had failed to relieve. In pruritis ani he regards epidural injections as more satisfactory than surgical procedures. His patients usually required from two to four injections four or five days apart. We have known a case of intractable pruritis ani and vulvæ of long standing to resist all other forms of treatment, and to clear up promptly after a single epidural injection. Others, however, do not respond after repeated injections, the percentage of such cases being probably about the same as in the treatment of sciatica.

Most of Cathelin's original work on injection of the sacral nerves was carried out in an endeavor to cure incontinence. He reported good results. We have treated a number of cases of enuresis and incontinence by sacral injections, but without signal success. However, a number of these persons are incontinent as a result of some underlying pathologic condition, disease in the bladder, prostatic urethra, or a definite nerve lesion. We have injected repeatedly in several cases both normal salt solution and weak solutions of novocain. A small number of cases of incontinence may be the result of minor nerve defects or they may be psychic or habitual. Advice as to general measures, together with an impressive procedure, such as sacral anæsthesia,

may have a temporary effect on some patients. In several cases definite cures were obtained, but it is difficult to determine the rationale of the treatment in these cases; in the majority no change was produced in the degree of the incontinence. It was impossible to determine that the sacral anæsthesia was definitely the cause of improvement in any case.

Obstetric Anæsthesia.—Stoeckel first investigated the value of epidural injections in the control of the pains of childbirth. By the use of 30 c.c. of a 0.5 per cent. novocain solution he materially reduced the pains of parturition, and in four cases terminated labor by the application of low forceps. Meeker and Bonar have recently made a study of the value of sacral nerve block anæsthesia, both by the single epidural injection and by the transsacral method in a series of ninety obstetric cases. From the standpoint of the anæsthetic, better results over a slightly longer period of time were obtained by the transsacral method, but the difficulties in the execution of transsacral block in the parturient make the epidural method the more practical, even though the height of anæsthesia is variable.

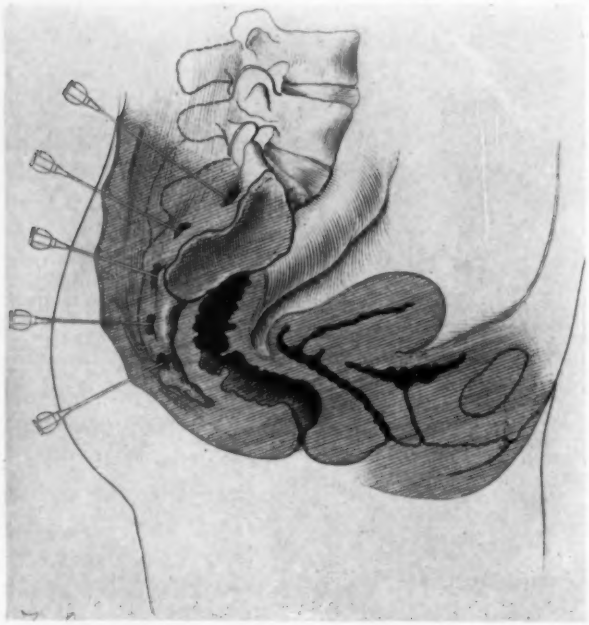

FIG. 9a.—Median longitudinal section of the pelvis anterior to the sacrum. The shaded portions represent the extent of anæsthesia. Note the variable thickness of tissues over the sacrum, and different direction of needles in entering the different foramina.

All obstetrical operations in which the operative field lies within the area innervated by the sacral nerves can be painlessly performed under sacral nerve block anæsthesia. The unmistakable relaxation of the pelvic floor facilitates any operation attempted by way of the genital tract. Twenty-one forceps deliveries have been performed, of which ten were low, eight middle, and three high. The perineal relaxation not only facilitates the application of the blades, but shortens the duration of the operation, and reduces the number of perineal tears. The obstetrician is not only able to apply traction during uterine contractions, but also to induce the patients to coöperate by bringing their abdominal muscles into action. Other intra-uterine manipulations have been done, and tears of the cervix and perineum painlessly repaired.

During normal labor the patients were instructed to bear down and urged to greater voluntary effort during the uterine contractions. Without proper

instruction and encouragement the parturients were likely to rest and delay the progress of birth until the pains were felt again.

The effect on the uterine contractions was inconstant. In the majority of cases there was almost complete cessation of contractions within ten minutes after the injection was completed. This diminution rarely lasted more than twenty minutes; the contractions then increased gradually in frequency, duration and intensity until after a short time they proceeded normally.

The greatest difficulty was the selection of the proper time to induce anæsthesia. There was a tendency to induce it too early in primipara and too late in multipara. In many cases, also, the time of delivery could not be accurately foretold, so that injections were repeated in some instances as many as three times. In average cases the maximal benefit from the injections was obtained when dilatation of the os had reached at least 7 cm. in primiparas and 4 cm. in multiparas. When, as the result of a patient's coöperation, labor terminated during the period of anæsthesia, it was without the usual noisy outcry, and often the patient was unaware that the baby had been born. Other patients felt dull pressure as the head slipped over the perineum. In many cases the perineum slid back from the head with such ease that the obstetrician was surprised, because a tear had seemed inevitable.

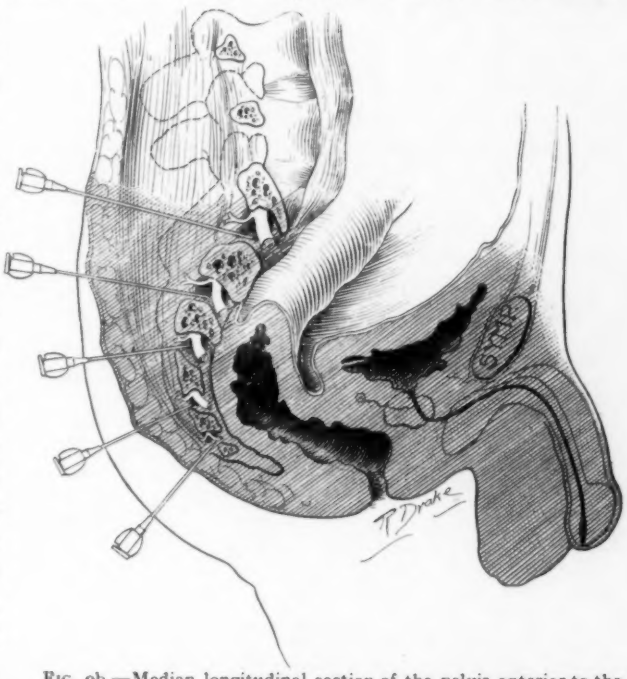

FIG. 9b.—Median longitudinal section of the pelvis anterior to the sacrum. The shaded portions represent the extent of anæsthesia. Note the variable thickness of tissues over the sacrum, and different direction of needles in entering the different foramina.

Surgical Anæsthesia.—It is in anæsthesia for operations involving the pelvic floor and viscera that block of the sacral nerves is most useful (Fig. 9). For two and one-half years, until January, 1924, we employed it in a large number of cases (Table I).

The total number of failures was 97 (5 per cent.). All cases in which the sacral anæsthesia had to be supplemented by general narcosis were regarded as failures, even if the stage of analgesia was not passed. Since the patients in this series were not selected, several were included who were mentally incompatible with local anæsthesia, and inhalation narcosis had to be

TABLE I

Block of the Sacral Nerves

	Cases	Failures	Per cent.
Operations on the prostate and bladder.			
Prostatectomy	270	16	5.92
Resection of bladder for carcinoma	32	3	9.37
Resection of bladder for diverticulum	8	3	37.5
Urologic examinations and manipulations	585	27	4.61
Operations on the rectum and anus.			
Posterior resection of rectum (Kraske)	151	18	11.92
Hemorrhoidectomy	325	6	1.84
Anal plastics (Fissures, fistulas, sinuses, excision of specimens, and so forth)	144	5	3.47
Operations on the vagina, uterus, and perineum.			
Vaginal hysterectomy	12	5	41.66
Perineorrhaphy	18	2	11.11
Amputation of cervix	15	3	20.
Combined perineorrhaphy, coloporrhaphy and repair of cervical tear or amputation of the cervix	54	4	7.4
Dilatation and curettage of the uterus	13	2	15.38
Obstetrics	90	1†	1.11
Therapy. (Sciatica, pruritis ani, enuresis, incontinence, and so forth)	54		
Miscellaneous	46	2	4.34
Total	1817	97	5.33

† Repeated injections were employed in obstetric work which accounts for the low incidence of failures.

resorted to for psychic reasons, even though block of the sacral nerves was complete. In a few instances the operation was delayed too long after block of the sacral nerves. In other instances the operation extended to structures outside of the anæsthetized field, as in transabdominal resection of the bladder and the combined abdominoperineal removal of cancer of the sigmoid.

Anæsthesia in Urologic Surgery.—The urologic surgeon, more often than any other, deals with persons having diminished function of the kidneys. An anæsthesia that will not appreciably increase the work of the kidneys, such as sacral anæsthesia, is desirable. The majority of patients presenting themselves for relief of prostatic hypertrophy or disease of the bladder, are usually well along in years, and frequently have also an associated urinary obstruction and renal insufficiency. Renal infection and chronic nephritis are common, and are responsible for the majority of deaths following prostatectomy and resection of the bladder. The anæsthesia employed is very closely associated with the incidence of undesirable post-operative sequelas in cases of urinary obstruction. Ether unquestionably predisposes to complications of the pulmonary and cardiorenal type, and the incidence of post-operative bleeding, which greatly increases the liability to urinary infection is, comparatively, quite high following spinal anæsthesia.

The epidural injection is very satisfactory and usually sufficient for perineal prostatectomy, but for operations on the bladder and for suprapubic prostatectomy, a complete transsacral nerve block is carried out, after which the patient is placed on his back for anæsthesia of the suprapubic region. A field block of the abdominal wall is employed, which results in greater relaxation than infiltration of the line of incision. This facilitates the use of retractors and results in better exposure.

The suprapubic field block is also applicable in the second stage of prostatectomy, in which the suprapubic sinus is to be dilated. Wheals are placed above each pubic spine, then along the outer margin of the rectus abdominalis muscle, usually three on each side. After piercing the skin at the lowest wheal, deep injections are made beneath the abdominal aponeurosis in the same straight line at the outer rectus sheath. Perforation of the aponeurosis is easily recognized by the increased resistance to the advancement of the needle. After perforation the needle is advanced no further, but an injection from 1 to 2 c.c. of solution is made. Successive perforation and injections are made in this manner along the entire outer margin of the rectus, almost as high as the umbilicus. When the deep injections have been completed, subcutaneous, fanwise injections are made in the same plane, joining the wheals together. The same procedure is repeated on the opposite side. A longer needle is then passed obliquely downward behind the pubic bone and into the space of Retzius, where an injection of 10 c.c. of solution is made.

For suprapubic field block, from 125 to 175 c.c. of a 0.5 per cent. novocain solution is necessary, depending on the size and obesity of the patient.

All patients have been placed in the Trendelenburg position; the same retractors and other instruments have been employed as in other methods of anæsthesia, and the operations performed in a similar manner.

Anæsthesia in Prostatectomy.—During the last three years 526 prostatectomies were performed: 270 under sacral anæsthesia, 187 under spinal anæsthesia, and sixty-nine under ether anæsthesia.

Transsacral anæsthesia is well tolerated by old men, and in no case were there undesirable complications attributable to the anæsthesia. Not infrequently the patient experiences a sense of distress or deep-seated pain during the period of enucleation of the prostate. This was especially noticeable in the subvesical and small, fibrous types of prostate, in which it was necessary to pull strongly on the tissues around the neck of the bladder in order to free the prostate. This discomfort was usually well borne, rarely lasted more than a few seconds, and the patient was without pain immediately after the enucleation. In sixteen cases (5.8 per cent. of 270) it was necessary to supplement the sacral anæsthetic with a general anæsthetic: ether, nitrous oxid, or ethylene. In several of these cases the general anæsthesia was only of short duration and was employed more for its psychic than for its anæsthetic effect. A certain number of patients object to being awake during the course of the operation and demand a general anæsthetic. These cases must necessarily be included with the group of either partial or complete

failures. The percentage, 5.8, probably represents the minimum of failures in this type of case.

A somewhat similar percentage, representing the group of actual failures of the anæsthetic, and cases in which general anæsthesia was demanded, is found in operations performed under spinal anæsthesia. In eleven (6.5 per cent.) of 167 prostatectomies performed under spinal anæsthesia, a general anæsthetic was required for completion of the operation.

The anæsthesia used in the cases of prostatectomy during the last three years, together with the immediate operative and late mortality, is shown in Table II. Statistics for cases in which spinal and ether anæsthesia were employed are given in order to form a basis of contrast among the three types of anæsthesia.

TABLE II

Comparison of Different Types of Anæsthesia for Prostatectomy

	Patients	Per cent.	Hospital mortality Patients	Per cent.
Sacral	270	51.33	9	3.33
Spinal	187	35.55	13	6.95
Ether	69	13.12	5	7.24
Total	526		27	

The introduction of sacral anæsthesia has unquestionably been a factor in the lowering of the operative mortality following prostatectomy. The operative mortality in cases in which sacral anæsthesia was employed is less than half that following prostatectomy under either ether or spinal anæsthesia. In patients recovering from operation, there was no difference in the late results following the different types of anæsthesia. Sacral anæsthesia does not entirely eliminate the possibility of respiratory infection, which, when it occurs following the administration of ether is usually attributed to pulmonary irritation from the anæsthetic. One patient in this series died from pneumonia and pericarditis forty days after operation. Sacral anæsthesia definitely eliminates the group of immediate deaths usually attributed to shock and cardiac disease. The earliest death in this series was on the fifth day, and followed post-operative hemorrhage and urinary infection; one death on the eighth day was due to uræmia, and the remaining seven deaths, in cases in which sacral anæsthesia had been employed, occurred from thirteen to forty days post-operatively, but in no case was there any definite causal relationship between the sacral anæsthesia and death.

Anæsthesia in Resection of the Bladder.—The success of sacral anæsthesia in resection of the bladder depends mainly on the extent of the resection and the tissues involved in the malignancy. Usually the sensation of the parietal peritoneum is not affected by sacral anæsthesia, but opening the peritoneum causes pain. Not infrequently, in tumors of the dome and posterior wall of the bladder, the peritoneum covering the bladder is involved and must be

resected. This usually requires a general anæsthetic. In the majority of cases of vesical neoplasm in which the peritoneum is opened, it is desirable to explore the abdominal cavity for metastasis, and a general anæsthetic is given. Occasionally a deep anæsthesia is produced which permits incision and exploration of the peritoneum; in certain cases intestinal resection may be carried out, but when the anæsthesia is induced in the usual manner, this is rare.

Anæsthesia in Operations for Carcinoma of the Bladder.—Sacral anæsthesia, together with suprapubic field block, was employed in forty-two operations for carcinoma of the bladder. In ten cases the tumor was too extensive for removal; radium emanations or needles containing radium were inserted in the growths in five cases, and in the remaining cases the bladder was drained. Ether was given in one case before the bladder was incised; there was a large tumor filling the entire bladder. In thirty-two cases resection of the bladder was carried out, in certain of which as much as one-half of the bladder was removed. Ether was required in three cases: in one case, that of a morphine addict who required ether before operation, a very small amount was given; in the second, a transperitoneal resection of the bladder was performed, and in the third, multiple tumors of the bladder were resected.

In four cases the peritoneum was opened and sutured to the base of the bladder below the tumorous growth, or else a transperitoneal resection was carried out. In only one of the four cases was the sacral anæsthesia insufficient to complete the operation. In three cases in which one ureter was transplanted to a normal area of the bladder, the sacral anæsthesia was sufficient. Only one patient died following operation. Death occurred on the seventh day from pneumonia and multiple abscesses in the heart and kidney.

Diverticula of the Bladder.—Diverticula of the bladder occasionally are very large, extending high up behind the bladder in an area not supplied by the sacral nerves. In dissecting out large diverticula an extensive area is usually opened, and the peritoneum is occasionally adherent to the sac. There were eight cases in which a diverticulum of the bladder was resected. Ether was required in three. In one of these the prostate was also removed (only one ounce of ether was given). In another there was a large diverticulum extending under the base of the bladder. In the third case the diverticulum was only of moderate size, but ether was necessary during the entire resection.

Urology.—In the majority of cases extensive anæsthesia is not necessary, but there is a certain percentage of patients who require complete anæsthesia of bladder and urethra. Etherization must be very deep to obtain relaxation of the bladder, and like spinal anæsthesia, it necessitates hospitalization. The restless movements of the patient under general anæsthesia greatly interfere with the accuracy and expediency of the examination. In contrast to this, the patient under sacral anæsthesia is perfectly quiet, conscious and able to coöperate, and the bladder is dilated to a point impossible save with some form of nerve blocking. The wall of the bladder is completely relaxed; there

is no pain or straining, which permits the surgeon to make a thorough, unhurried examination of the bladder and ureters. Sacral anæsthesia was induced in 585 cases for urologic examination. (Table III.)

TABLE III

Results of Sacral Anæsthesia in Patients Operated on, Treated, or Examined for Urologic Conditions

	Cases	Results	
		Satisfactory	Failures
Operations and treatments.			
Radium needles	111	105	6
Transvesical treatment of bladder tumors:			
Fulguration	31	31	0
Radium emanations	27	27	0
Urethral operations	25	24	1
Litholapaxy	31	30	1
Manipulation of ureteral stones	51	51	0
Prostatic punch	17	17	0
Cystoscopic examinations:			
Tuberculous cystitis	74	72	2
Malignant cystitis	63	58	5
Alkali phosphate cystitis	9	9	0
Pyelocystitis	126	115	11
Bladder stone	8	8	0
Submucous ulcer	2	2	0
Miscellaneous	10	10	0
Total	585	559	26

As a general rule, a single caudal injection gives sufficient anæsthesia for a complete cystoscopic examination. In cases in which a single caudal injection is insufficient, or in which it is impossible to enter the sacral hiatus, it is necessary to inject the lateral foramina. Usually an injection of the first and second nerves is sufficient.

Failure to induce complete anæsthesia by caudal injection most commonly occurs in small contracted bladders, such as are found in extensive tuberculous infection. In cases of malignant tumors of the bladder, the growth may involve a large area of the bladder wall or may have extended through the bladder wall to neighboring structures. In such cases, distention of the bladder may affect structures not anæsthetized by a caudal injection. There were no failures in cases in which either the first or the second, or all of the lateral foramina were injected together with the caudal foramen.

Sacral anæsthesia is usually very satisfactory in irritable, inflamed bladders, especially those of tuberculous origin. In contracted, painful bladders which must be emptied every ten to fifteen minutes, the instrument is passed painlessly, the anæsthesia permitting a distention of from 100 to 150 c.c. during the entire examination, without a tendency to discharge. With sacral

anæsthesia, it is possible to add the extra ounce or two of fluid which usually determines whether cystoscopic examination is to be a success or a failure. A distention may be produced with sacral anæsthesia sufficient to flatten the folds of mucosa and expose the entire surface of the bladder. There is paralysis of the sensory arc, and the reflex spasm, that often makes complete examination impossible, is absent. The patient rests quietly; stertorous breathing and the shifting bladder walls under deep narcosis are absent.

Sacral anæsthesia may be substituted for the usual perineal infiltration preliminary to the introduction of radium needles into a carcinomatous prostate. With a local infiltration it is difficult to eliminate deep pressure pains caused by the needle passing through the board-like malignant tissues of the capsule and prostate gland. After blocking the sacral nerves, the anæsthesia of the perineal tissues, the prostate and its covering is so complete that the needles are often passed without the knowledge of the patient. More radium needles may be inserted than when a local infiltration is used; the radium-containing tips are more accurately placed and the field of operation is not obscured by the œdema caused by the infiltrating solutions.

In the majority of cases of benign papilloma of the bladder, fulguration may be carried out without extensive anæsthesia, but occasionally there is an associated cystitis which will not permit sufficient distention for a satisfactory fulguration. In a number of cases, multiple papillomas were fulgurated over a long period of time without discomfort to the patients.

In cases of lithopaxy, when washing out stone fragments, it is necessary to remember that the musculature of the bladder is partially paralyzed by the anæsthetic, and cannot readily expel the water and particles of crushed stone. The Bigelow evacuator has been used satisfactorily to overcome this difficulty.

Temporary paralysis of the sphincter muscle may produce a slight incontinence, particularly after the introduction of a large instrument such as a lithotrite. This relaxation usually disappears with the return of sensation.

Sacral anæsthesia produces excellent relaxation of the lower ureter and permits the manipulation of ureteral stones. In certain cases a number of ureteral catheters may be inserted readily without causing the patient discomfort. Occasionally there is relaxation of the lower ureteral segment and a spasm of the upper ureter which causes an impassable angulation. This angulation may occur following an injection of all the lateral foramina as well as after a single caudal injection. In some persons it is present repeatedly following subsequent injections, making it impossible to introduce the ureteral catheter. In such cases, some other type of anæsthesia should be employed.

Operations on the Rectum.—Sacral anæsthesia has been repeatedly employed for hemorrhoidectomy, the usual type of operation being clamp and cautery of the internal hemorrhoids, and excision and suture of the external. Dilatation of the anal sphincter is one of the characteristic features of the method, reducing to a minimum the use of manual or instrumental dilatation. Plastic operations on the anal sphincters, removal of rectal polypi, dilatation

or rectal strictures, excision of specimens from rectal tumors for diagnosis, painful proctoscopy, amputation of the prolapsed rectum, and posterior resection (Kraske) of the rectum, have all been performed many times under this anæsthesia.

The anæsthesia in the minor operations on the terminal rectum offers no special problem since the patients are usually in good general condition. Among patients suffering from cancer of the rectum, however, are many with associated nephritis, pulmonary and cardiac complications, general weakness, malignant cachexia, and secondary anæmia. In such conditions as these the advisability of eliminating the extra burden imposed on the vital organs by a general anæsthetic is quite obvious. The anæsthetic hazard in these cases may be considerably lessened by the use of sacral nerve block anæsthesia, which does not, as a rule, affect the general condition of the patient.

Buie has recently completed an interesting statistical study of the surgical results in carcinoma of the rectum at the Mayo Clinic between January, 1910, and December, 1922.* He showed that the surgeons are becoming more radical in their attempt to help more patients, which is evidenced by the increase in the operability of cancers of the rectum and rectosigmoid from 56 to 84 per cent. during this period. In spite of the extension of operability, the mortality has gradually decreased. It is quite probable that the improved preoperative preparation and the improvement in surgical methods and technic are to a great degree responsible for this gratifying result. The increasing use of the two-stage operation is doubtless a contributing factor, while the use of sacral anæsthesia has materially reduced the risk of operation. The height of the growth is also a factor influencing mortality, which is 18.3 per cent. for growths in the rectosigmoid, and 7.44 per cent. for those in the rectum. We have made a statistical study of posterior resections of the carcinomatous rectum over a period of six years, ending January, 1924. The total number of such operations during this period was 392, with a postoperative mortality of thirty-four (8 per cent.). Any death occurring in the hospital following operation was charged as an operative mortality, even if the complications which caused death arose in the lung, kidney or other organs. One hundred and fifty-one resections were performed under sacral anæsthesia, with a mortality of 7.3 per cent., and 241 were performed under general anæsthesia, with a mortality of 9.5 per cent.

Among the 151 nerve block cases we listed eighteen as failures because the administration of a general anæsthetic was necessary at a certain stage of the operation. When there is intolerable pain it is due to excessive traction on the bowel necessary to bring a high-lying growth down so that clamps may be applied above it. This traction is probably on the mesosigmoid, involving the hypogastric nerve plexus, and cannot be controlled by block of the three lower lumbar nerves. This same trouble is observed with low spinal anæsthesia. Block of the sacral nerves alone anæsthetizes the entire pelvic floor, including the pelvic peritoneum, so that there should be no pain when this is opened, stripped from the rectum, or closed.

Sacral nerve block is not appropriate for the removal of high-lying growths by the combined abdominoperineal method. One of our failures was in the case of a sigmoidal growth which had produced complete intestinal obstruction for five days by intussusception. The sacral nerves were blocked and the abdominal wall anæsthetized by field block. The intra-abdominal manipulations were painful, necessitating the use of ether, since no intra-abdominal anæsthesia was afforded by the local anæsthetic procedures.

Gynæcologic Operations.—Operations performed on the genital tract under sacral nerve block have included carcinomatous ulcers of the vulva, perineorrhaphy, complete vaginectomy, the Bovée and Clark operations for cystocele, trachelorrhaphy, dilatation and curettage with insertion of the Baldwin tube, repair of vesicovaginal fistulas, excision of vaginal tumors, the Watkins interposition operation, and the Mayo vaginal hysterectomy.

In malignant growths of the vulva it is best not to rely on circular infiltration because of the wide extirpation necessary and the possibility of the spread of cancerous foci. Sacral nerve block affords a very wide area of anæsthesia, and is very efficient when used alone in these cases, unless the external anterior parts of the labia majora are to be included in the operative field, in which case infiltration from the pubic spines must also be practised.

Vaginectomy has been performed in relaxed pelvic floors after hysterectomy in which the pelvic peritoneum was painlessly opened and closed. Repair of cystocele may be painlessly performed. Multiple perineal operations, such as dilatation and curettage, trachelorrhaphy, perineorrhaphy and hemorrhoidectomy, have been performed on the same patient under one anæsthesia.

It is in the Watkins interposition operation and the Mayo vaginal hysterectomy that the borderline of usefulness of the sacral method is reached. In these operations, particularly the hysterectomy, the most difficult problem is the prevention of traction pain. Vaginal hysterectomy in this series was most commonly performed for uterine prolapse. The majority of the patients were obese, and had passed the menopause. The anæsthesia of the pelvic floor was usually satisfactory and the peritoneal cavity could be opened painlessly. Delivery of the fundus of the uterus through the vaginal and peritoneal opening for clamping of the broad ligaments is usually the stage at which most pain occurs. Usually a small gauze pack is temporarily placed in the peritoneal cavity to prevent the intestines from protruding. Structures not supplied by sacral nerves, and consequently not anæsthetized, are thus encroached on. There is also tension in approximating and suturing the broad ligaments after the uterus has been removed.

This pain from traction on the broad ligaments cannot be controlled by parametric injections, since the same amount of tension is still present beyond the area infiltrated, the parametric injections serving only to anæsthetize the uterus itself. In cases of marked relaxation and complete prolapse, therefore, the anæsthesia is usually sufficient for hysterectomy and may be followed by perineorrhaphy.

There were twelve cases of vaginal hysterectomy in this series. Seven of the patients were past sixty, and two past seventy years of age. Three weighed over 200 pounds. In five cases it was necessary to add ether or gas oxygen to the sacral anæsthesia during the deep manipulations, the combined method probably offering a bigger margin of safety in poor risk cases than general narcosis alone.

Miscellaneous Operations.—Various minor operations have been carried out on the urethra, vagina, and rectum, and in the superficial tissues of the buttocks and gluteal folds. Vesicovaginal fistulas were repaired in twelve cases. There was almost always complete anæsthesia of the vagina and of the lower portions of the bladder. In an occasional case, in which multiple repairs had been previously carried out and there was an extensive defect requiring considerable tension to close over, discomfort was experienced by the patient, but in no case was it sufficient to necessitate a general anæsthetic. In twelve cases a ureteral plastic operation for incontinence was performed. In the majority of cases the Kelly type of plastic repair with plication of the muscular covering on the posterior wall of the urethra was made. Vaginal operations were performed in nine cases: in one case a carcinoma of the vulva and vaginal wall was removed. In a second case a vaginectomy was performed, and in the others various types of plastic operations.

In three cases coccygectomy was performed. The area at the tip of the coccyx, anæsthetized by the lower sacral nerves, is the first to become anæsthetized, and no discomfort was caused by the removal of this bone. In three cases pilonidal sinuses were excised, and in two, cysts of Bartholin's glands were removed.

Complications and Sequelæ.—The concomitant complications of sacral anæsthesia are, as a rule, not severe, provided the procedure has been properly executed. Most patients react more or less to the injection of novocain-epinephrin solutions into the sacral canal and foramina, the severity of the reaction depending on the strength and quantity of the solution, the amount of epinephrin, the speed with which the injection is made, and especially the sensitiveness of the patient to the effects of epinephrin and novocain.

The most common complications are rapid pulse and palpitation of the heart, most likely due to the epinephrin, although Lowsley reports the same effects in using a 2 per cent. novocain solution without epinephrin. Increase in the pulse rate from 20 to 30 beats a minute is usual, the patient at the same time experiencing a pounding sensation with the heart action. Sometimes there is precordial distress, and more rarely a sensation of constriction across the chest. In a few instances the pulse has been very markedly accelerated, in one instance reaching 180 for a time. A rise in blood pressure with the increase in pulse rate is usual. This is observed during, and immediately after, the injection and lasts but a few minutes. These complications, when marked, may be accompanied by an increased respiratory rate and dyspnœa, pallor, perspiration, and a feeling of giddiness. Still more rarely there may

be nausea and vomiting. Four patients had short periods of excitement, the longest being fifteen minutes. Patients may very rarely have a definite psychosis and require restraint. These four were somewhat confused temporarily, but after the conclusion of the excitement stages the operations were performed without incident. When such sequelæ appear, the injection should be stopped until they improve. Judging from our experience, they need cause no serious concern.

Cases of rigor, convulsion, syncope and collapse have been reported. Death has followed high sacral anæsthesia. There is no actual danger in the method when the correct technic is used and the anæsthesia restricted to the nerve distribution of the pelvic organs.

There may be pain and tenderness at the site of the sacral injections for from four to five days, depending on the amount of searching necessary to locate the foramina. In cases of prostatectomy this was aggravated by the patients bearing their weight on the sacral region, and soiling with urine. There were three cases of infection of the area of injection with sloughing of the tissues over an area from 2 to 4 cm. in diameter. All three cases followed prostatectomy in thin patients. Since then such patients have been supplied with air cushions, and no further trouble has arisen.

SUMMARY

Anæsthesia of the sacral nerves is entirely satisfactory for most operations that are to be carried out in the field supplied by the sacral nerves. It entails practically no immediate or late risk for the patient, and has been proved very efficient and satisfactory.

A knowledge of the posterior surface of both normal and abnormal sacrums and contiguous bony prominences is necessary in order to employ sacral anæsthesia successfully. Certain variations of the structure of the sacrum may influence the ease of induction or the result of the anæsthetic. The size of the sacral hiatus is variable. In the majority of sacrums the closure of the hiatus is over the fourth, occasionally over the third, and rarely over the first or second sacral vertebra. In a small number of cases there is an entire deficiency of the roof of the sacral canal.

The normal sacrum is made up of five vertebra. Sacrums of six segments are frequently encountered, but sacrums of four segments are much rarer, only one such specimen being encountered in our series. The number of foramina to be injected varies with the number of segments. In the normal sacrum there are four foramina on each side. The foramina in the second sacral segment is the largest, and usually the most readily located and entered. The individual foramina, usually circular in shape, decrease in diameter from the first to the last segment.

The sacrum is usually flattened above and has quite a pronounced curve below the third segment. Traumatic, or developmental deformities of the sacrum are extremely rare and usually do not interfere with the induction of the anæsthesia.

Palpation of the bony prominences gives the most accurate knowledge of the location of the sacral hiatus and foramina. The posterosuperior iliac spines are the most readily accessible bony prominences and they usually bear a constant relationship to lateral foramina.

In certain cases in which the operation is to be performed in a field supplied by the lower sacral nerves, a single injection of novocain in the sacral hiatus is sufficient. In the majority of cases the lateral foramina and the contained nerves, as well as the sacral hiatus, were injected, inducing immediate anæsthesia which is satisfactory in practically all cases. A 1 per cent. solution of novocain, to which was added a small amount of epinephrin, was employed. Our experience has not indicated that the combination of other salts with the novocain results in a more satisfactory anæsthesia.

Sacral anæsthesia was employed in 1817 cases at the Mayo Clinic. Satisfactory anæsthesia was not obtained in 97 (5.33 per cent.) of the cases. The highest percentage of failures occurred in cases in which extrapelvic structures, not supplied by sacral nerves, were encountered.

Sacral injections for therapeutic purposes were carried out in the treatment of nervous conditions, and a proportion of cases of sciatica were definitely improved, but they were of very little practical value in the treatment of urinary disorders such as incontinence and enuresis.

In obstetric cases sacral anæsthesia has proved very satisfactory in reducing the perineal pain incident to the passage of the child, and it also permits a satisfactory relaxation of the perineal muscles, which greatly reduces the tendency to tear. Obstetric operations and manipulations may be painlessly performed under this anæsthesia.

Anæsthesia of the sacral nerves has proved entirely satisfactory for most surgical procedures on the pelvic floor and viscera. It is especially satisfactory in urologic cases. The mortality following operations on the bladder, prostate and rectum is markedly reduced in cases in which sacral anæsthesia is employed. In urologic surgery many patients are encountered having a reduced renal function. Sacral anæsthesia, which in most cases does not increase the work of the kidneys, is especially desirable.

Cystoscopic examinations and urethral and bladder manipulations may be readily carried out under sacral anæsthesia. Small contracted, infected and malignant bladders may be dilated sufficiently to make a complete, unhurried examination without discomfort to the patient. A single injection in the hiatus sacralis is sufficient for the majority of cystoscopic examinations and manipulations.

Undesirable complications and sequelæ are exceedingly rare following sacral anæsthesia. In no case did any permanent or lasting trouble develop. Occasionally in debilitated patients slight toxic symptoms followed the injection of the novocain-epinephrin solution, but these readily passed off; in the majority of cases the patient was perfectly well following operation and had no ill effects from the anæsthetic.

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ADOLESCENT COXA VARA*

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Coxa vara is a deformity of the hip which is characterized by a depression of the neck of the femur in relation to the shaft. The angle which the neck makes with the diaphysis is altered from 130° to more or less a right angle; the bending in the adolescent type takes place at, or close to, the epiphysis. Besides the lowering of the head, this type presents an incurvation backward, accompanied by torsion of the neck in its longitudinal axis.

Historical.—Fiorani, in 1881, first gave a clinical description of coxa vara, and Müller, in 1888, first established the relationship between the clinical syndrome and incurvation of the neck of the femur; his description is said to be based on a specimen obtained by resection undertaken for supposed tuberculosis of the hip. Kocher, in 1894, at a surgical congress in Berlin, first suggested the name coxa vara for the condition. Kermisson, in 1897, published a paper on the differential diagnosis of coxa vara and tuberculous disease of the hip. Up to this time the only etiologic factor, apart from the congenital type, was rickets; other hypotheses now began to arise, such as the static, infectious, and traumatic, the last being intimately associated with the name of Whitman, who asserted that coxa vara often, if not always, occurs in adolescents, consequent to fracture or slipping of the epiphysis of the neck of the femur.

General Considerations.—The angles of inclination, of declination, of Alsberg, and of extension may be used in the diagnosis and in measuring the degree of coxa vara. The angles of inclination and Alsberg are common to all types of coxa vara, the other two angles are entirely confined to the epiphyseal or adolescent type, the former measuring the incurvation of the neck, the latter the rotation of the neck in its longitudinal axis. The angle of extension is most important from the point of view of diagnosis, and is measured by noting the increase in the range of extension, without producing lumbar lordosis by Thomas' test, with the patient at the edge of the table, and noting the increase in the range of extension.

Pathology.—The bending seems to take place at or near the epiphyseal line; the femoral head seems lowered, but in reality it is the trochanter which is raised. Besides lowering the neck, it is incurved behind, and usually twisted on its longitudinal axis. The neck seems to bend just at the cotyloid margin, so that the posterior surface appears shortened and the anterior surface

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prominent and lengthened. In the X-ray [1] the head appears distinctly semi-lunar in outline, the cotyloid cavity lengthened longitudinally and diminished transversely, taking the form of an ellipse. In a certain proportion of cases there are also chronic arthritic changes. The cartilaginous covering of the femoral head disappears from its lower part, and sometimes encroaches on the superior border of the neck. The angle of declination, usually 12°, may become negative.

The factor [2] at work in producing the incurvation of the neck, and its

FIG. 1.—Röntgenogram before treatment.

twisting on a longitudinal axis is the iliofemoral ligament, one of the strongest in the body and extending from the anterior inferior spine to the anterior intertrochanteric line. This ligament fixes the leg in extension and offers considerable resistance to the external rotators of the thigh. When both attachments are approximated by a movement upward of the great trochanter, hyperextension takes place, and the external rotators take over the mastery, producing external rotation of the leg as a whole. This appears to give a satisfactory explanation of the incurvation of the neck, and the rotation of the neck on a longitudinal axis, both of which are really secondary to the elevation of the great trochanter.

The influence of injury is still a much debated point; in most cases there is a history of injury, sometimes even a slight one, in other cases repeated injuries of a minor nature; in yet a smaller group there is no history of injury. The traumatic theory is not sufficient in itself to explain this type of coxa vara. First, there appears to be a juxta-epiphyseal softening and a slow giving way of the neck in that region, which may or may not have been accelerated by slight injury. A large proportion appear to give way gradually for a considerable period; others after giving way slowly for a time appear to give

FIG. 2.—Röntgenogram after treatment.

way quickly, probably owing to trauma. Such juxta-epiphyseal softening appears to be something of the nature of late rickets.

There is usually an elevation in the superior border of the neck, said to be an osseous reinforcement. It appears to be too far out for the epiphysis, but probably is the site of the original displacement.

The neck shows modification of structure according to Wolf's law, softening and atrophy of the superior part, with reinforcement by compact bone in its lower part.

Clinical Study.—Adolescent coxa vara comes on usually between the ages of twelve and eighteen years. The onset is sometimes marked by pain, but

often is quite insidious. The pain is usually associated with the rapid slipping, and sometimes at this stage it may be mistaken for coxalgia. The pain of a gradually produced coxa vara is slight; the deformity comes on gradually, elevation of the pelvis takes place on the affected side, and limping and limitation of movement result. The region of the hip is deformed, the great trochanter rises to a higher level than its fellow, and there is both apparent and real shortening.

Both active and passive movements are limited according to the extent of

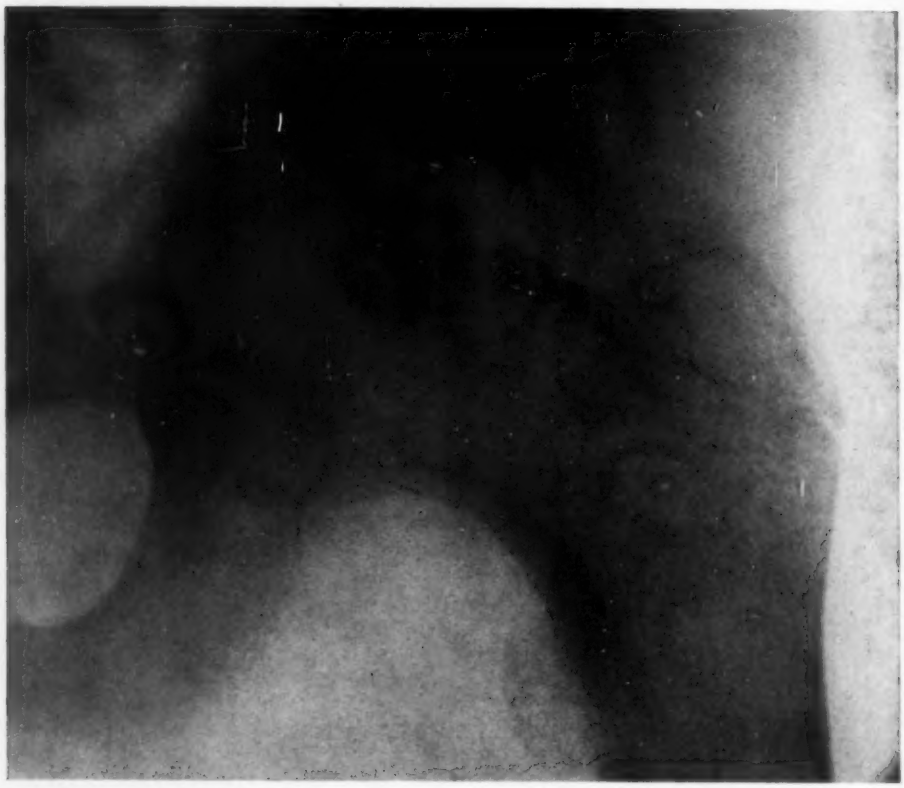

FIG. 3.—Röntgenogram four months after treatment.

the deformity. The great trochanter rises above Nélaton's line and is further back than normal. Bimanual palpation, that is, the thumbs on the anterior superior iliac spines, and the forefingers on the tips of the great trochanters, gives a good approximate estimate of the relationship on the two sides.

The triple deformity of the femoral neck produces a three-fold limitation of movement, abduction, flexion and internal rotation. In extreme cases the abduction is limited by the great trochanter coming in contact with the dorsum ilii.

There is an increase in the range of extension which, without producing an under lumbar lordosis, is of value in differentiating the condition from

coxalgia. If untreated, the deformity steadily progresses and may go on for years, sometimes until the epiphysis is united, but often a much better result is obtained when the slip gives way suddenly and produces marked deformity, than if the hip gives way slowly.

Arthritis a Complication.—In certain cases in which there has been arthritis of one or both hips, the neck seems to soften adjacent to the head, and a slow bending takes place, producing the triple deformity, as in adolescent coxa vara, in some cases slowly, in others suddenly.

Treatment.—According to Whitman, there are three principles of treatment: (1) Correction of deformity, (2) fixation of fragments, and (3) protection during the period of reconstruction. Repair of solutions of continuity in the neck of the femur takes place by internal callus alone; external callus plays no part in the union; therefore the quality of fixation must be good, and this can be obtained by direct pressure.

From the standpoint of treatment, patients with adolescent coxa vara may be classified in two groups: (1) Those seen early before the bones have been allowed to fix in the deformed position, and (2) those seen late when bony union has been allowed to take place in the deformed position.

Group 1.—Under general anæsthesia, tenotomy of the adductors, forcible abduction and slight internal rotation are accomplished. This treatment is applicable to cases of sudden or gradual displacement; in both types a slight, soft crepitus is felt as the bones go into apposition. Fixation with the patient under anæsthesia, wide abduction with slight internal rotation for three months, and weight-bearing caliper for six months, is the usual form of treatment.

Group 2.—If the deformity has been allowed to become fixed by bony union uncorrected, subtrochanteric osteotomy and wide abduction should be accomplished. The abduction should be confirmed by the X-ray, so that the new angle formed by the neck and the shaft forms about 125° to 130°; the hip should then be fixed for three months in plaster. When there are marked arthritic changes associated with coxa vara, especially in bilateral cases, the head of the femur should be excised.

Early diagnosis is important. All cases of slight injury to the hip during adolescence should be carefully X-rayed, and a weight-bearing caliper applied, if there is any suspicion of coxa vara.

ABSTRACT OF A TYPICAL CASE

J. M., a boy aged fifteen years, was examined June 12, 1922. Two months before he had fallen from a tree; he got up and walked home, but he limped and felt slight pain, which continued. Six weeks later he again fell, and since then had been unable to stand or walk.

Examination.—The right leg was in the position of eversion and adduction. The great trochanter was displaced above Nélaton's line. There were a few degrees of painless movement in all directions, but mostly in extension. The X-ray revealed adolescent coxa vara of the right hip. Operation was performed June 14, 1922. Tenotomy of adductors and forcible abduction with internal rotation were accomplished. October 3, 1922, the

patient was allowed to get up in a weight-bearing caliper. April 14, 1923, the caliper was discontinued. The range of movement in the hip was good (Figs. 1, 2 and 3).

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THE RECONSTRUCTION OPERATION FOR ARTHRITIS DEFORMANS OF THE HIP-JOINT*

By Royal Whitman, M.D.
of New York, N. Y.

The reconstruction operation may be defined as a mechanical adaptation of a hip-joint disabled by injury or disease to the essential requirements of locomotion. It was originally devised for ununited fracture, particularly for a class of cases in which the neck of the femur had been in great part absorbed or worn away, so that direct union of the fragments by any means was doubtful, and in which, even at best, function must be greatly impaired by loss of the neck and consequent limitation of abduction. In this operation the head of the femur is removed and the trochanter is cut from the shaft in an oblique direction with all its attached muscles so that the additional area thus obtained, together with the part of the neck that remains, may provide a secure weight-bearing surface. The reconstructed neck having been inserted into the acetabulum, the limb is abducted sufficiently to permit the trochanter to be drawn down and implanted upon the outer surface of the shaft. Thus by muscular tension, security of the new articulation is maintained, while the reconstructed neck and the transplanted trochanter restore the leverage for the hip muscles and permit a range of controlled motion that enables the patient to walk with security and to sit with comfort.†

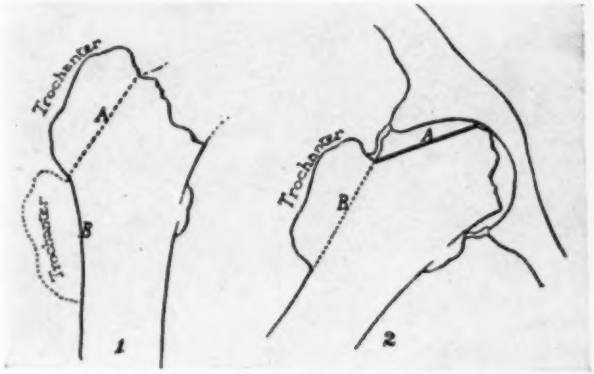

Fig. 1.—Showing complete loss of the neck after fracture of the neck of the femur. 2. Shows the reconstructed neck and the area obtained from removal and transplantation of the trochanter.

Recently the scope of the operation has been enlarged to include a number of other conditions, such as pathological dislocations or subluxations secondary to disease, in which the articulation has been in part destroyed. Cases of this class which require reformation of the acetabulum are not included in the present discussion, which is limited to the operative treatment of arthritis deformans.

In typical cases of this type, the disease practically limited to the hip-joint, is of the so-called hypertrophic or degenerative form, affecting primarily the cartilage and underlying bone of the femoral head, as distinct from the generalized or infective group in which the soft parts are primarily involved.

In characteristic cases the disease is of long standing, beginning with

* Demonstrated before the New York Surgical Society, December 12, 1923.

† Surg., Gyn. and Obst., June, 1921.

indefinite symptoms of pain and discomfort in the joint and limb—"sciatic rheumatism."

The limitation of motion and the discomfort on changing from rest to activity become more noticeable and eventually the limb assumes an attitude of flexion and adduction, the compensatory upward tilting of the pelvis being mistaken usually, for actual shortening. At this stage a crutch or cane is required for locomotion and the patient, from an industrial standpoint, is practically disabled.

FIG. 2.—Case I. X-ray taken ten months after the operation, showing the extremity of the neck and the transplanted trochanter.

The etiology is obscure, but whatever may be the remote predisposing or exciting causes of the disease, constitutional or local, irregularities of the joint surfaces, either the result of congenital malformation or induced a great influence on its by injury or disease, have inception, and more especially on its progress when established, the articulation being gradually worn away and distorted by friction and pressure.

Of the seven cases that form the basis of this paper, five were in females. Three of the seven, including the two males, were typical cases of "morbus coxæ senilis" both as to age, symptoms and pathological appearances. The fourth was in a woman of forty-eight years of age. The symptoms had become persistent twelve years before admission, but she had had since childhood, occasional discomfort in the joint. The pathological changes were similar to those of the preceding cases, but the cause may have been an incongruity induced by disease or deformity acquired in early life.

In the fifth case, a woman of middle age, the symptoms had followed a fall on the hip four years before admission which, if a fracture, had not caused immediate disability. At the operation only a part of the head and neck remained, indicating apparently a so-called absorption following injury.

In the sixth case, in a woman of forty-five years of age, the symptoms

were first noticed after the birth of a child five years before, but if they were the result of infection, it was of a very subacute type.

The seventh case was in a woman forty years of age. The symptoms had been noted eight years before and had increased noticeably after the birth of a child two years later.

It would appear that the disease, at least in the typical form, usually begins in the head of the femur and that the cartilage first disappears on its inner and upper surface. The underlying bone loses its resistance and becomes flattened or otherwise distorted. The acetabulum is less directly involved, and the distortion is not marked until the flexion and adduction of the limb concentrates the pressure on its outer and upper border, permitting a subluxation of the joint. It may be noted in this connection that the museum specimens pictured in the text-books are usually of the most advanced type of the disease and quite unrepresentative of the class of cases under consideration.

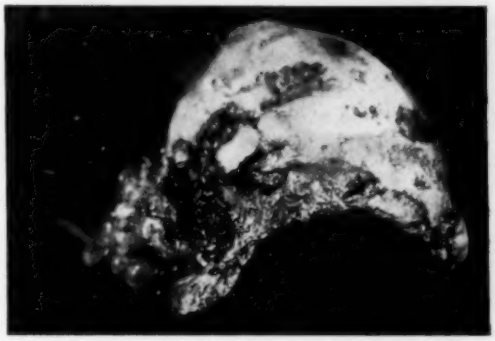

FIG. 3.—Case I. Showing the pathological changes in the head and the area removed.

If a diagnosis were made at the inception of the disease, after the removal of all possible sources of infection, internal medication, combined with measures designed to improve nutrition, to check the tendency to deformity and to regulate the strain and pressure on the joint, might check progressive disability. But in advanced cases, such as those under consideration, treatment by rest or traction or splinting can be but palliative; for from the character of the disease it is evident that only removal of friction, the direct cause of pain and of the progression of the destructive process can assure permanent relief.

The usual operative remedy has been arthrodesis to induce bony ankylosis. This, however, is an uncertain outcome because abduction of the limb, the attitude of election, separates the upper surface of the head from the acetabular roof to which it should be apposed in order to secure union, and in a large proportion of cases, although sufficient restriction of motion may be assured after prolonged fixation to relieve pain, there is recurrence of a certain degree of flexion and adduction deformity after the support is removed. Fixation at the hip in patients of this class entails also the disadvantage that assistance is required in dressing.

The only alternative to arthrodesis has been resection, an operation recently described by Groves (*Br. J. Surg.*, Oct., 1923). The head of the bone is removed through a posterior incision and the extremity of the neck, covered with a fascial flap, is inserted into the acetabulum. This operation is effective in removing the disease, but it is defective from the functional standpoint because the trochanter is brought into contact with the rim of the acetabulum thus mechanically limiting abduction. This is a very important

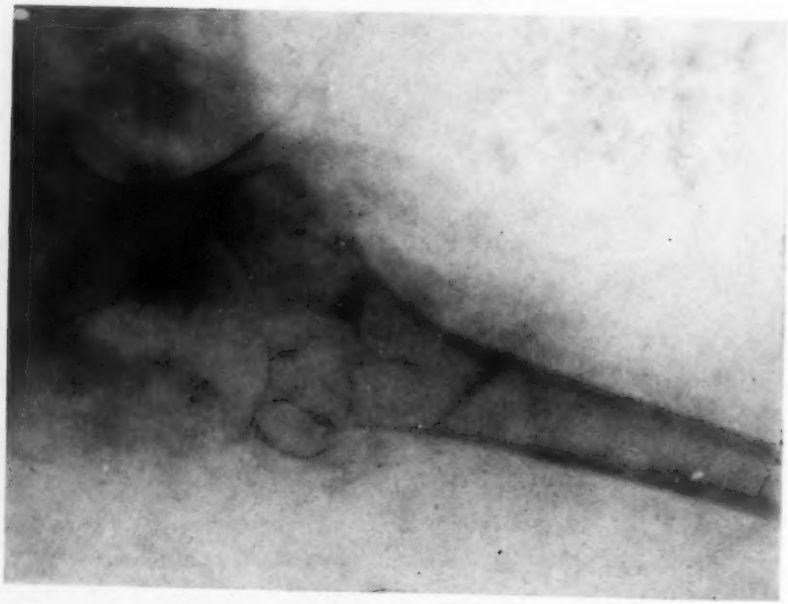

FIG. 5.—Case IV. After operation.

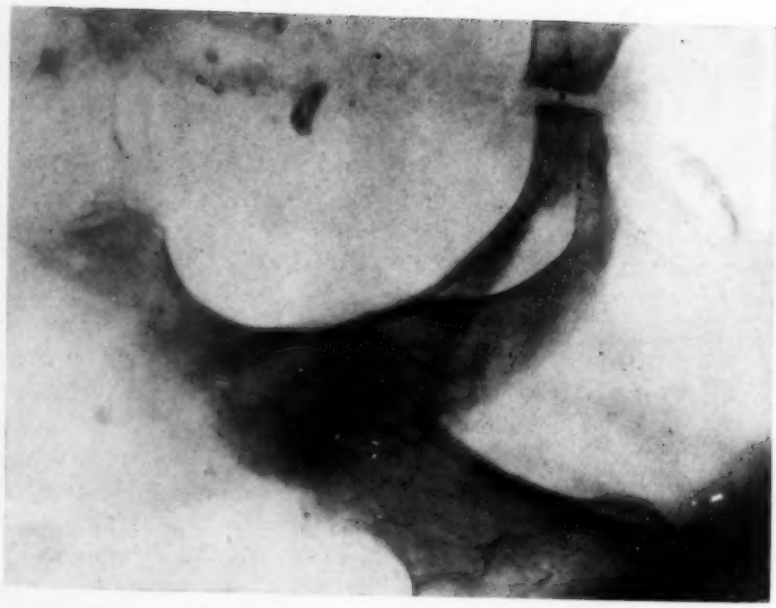

FIG. 4.—Case IV. Showing the expansion of the head and the atrophy of the bone.

FIG. 6.—Case III. Showing hypertrophy and subluxation.

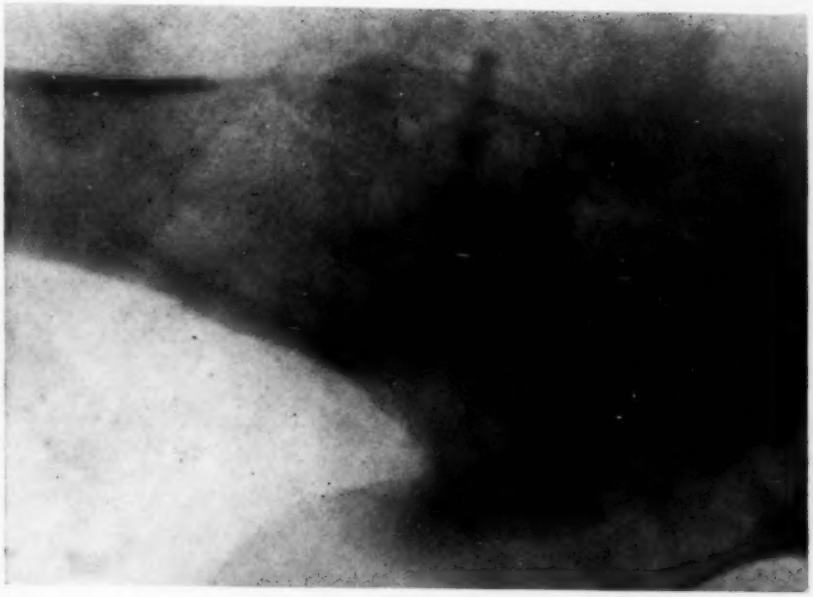

FIG. 7.—Case III. After operation, illustrating fixation of the trochanter by a bone screw. Operation performed by Doctor Wagner of the Assistant Staff.

defect because in proportion to lessened muscular control, physical weakness or limited motion, the more essential for security is the crutch-like support of an abducted limb. This ability to spread the legs apart is dependent upon the length and angle of the femoral neck and the lateral projection of the trochanter which assures muscular leverage.

In considering the operative relief of arthritis deformans at the hip-joint from the functional standpoint, the objects to be attained are, in order of importance: 1st, the removal of a destructive process and thus to check progressive disability; 2nd, security in weight bearing, which implies a sufficient range of abduction; 3rd, the restoration of a fair degree of voluntary motion.

FIG. 8.—Typical arthritis deformans in a man of sixty years, showing subluxation. Operation, November 19, 1923. Plastic spica removed, December 17. Patient free from pain and walking with crutches on January 7, 1924. Crutches discarded, March 19, 1924. Now walks with cane and considers the result perfectly satisfactory.

From this standpoint the reconstruction operation has manifest advantages over other treatment. It is conducted as follows:

The incision is in the shape of a half U, begins an inch below and behind the anterior superior spine and crosses the femur at a point about three inches below the apex of the trochanter. The deep fascia is dissected backward and the interval between the tensor vaginæ femoris and gluteus medius opened, exposing the capsule. With a wide chisel the base of the trochanter is then separated from the shaft in the line of the neck and with its attached muscles is turned upward. The capsule is opened and with a large curved chisel the greater part of the head is removed, the design being to include all the cartilage, the marginal exostoses and as much of the underlying bone as may be involved in the degenerative process, including in some instances a part and in others, all of the femoral head. This articulating extremity is made round and smooth with a chisel and file, and is then inserted into the acetabulum the cartilage of which, except on the outer and superior margin, is usually fairly normal. And since in the abducted attitude there is little direct contact between the two there would seem to be no necessity for covering the neck with fascia, although this has been done in some instances in which the bone seemed particularly soft. A thin

section of bone with the overlying muscle in the form of a flap, is turned back from the upper and outer surface of the shaft and the limb having been adducted sufficiently, the trochanter is brought down so that its base may be apposed to the bare surface on the outer part of the shaft, where it is fixed by deep sutures through the overlying tissues or by a bone screw. The wound is closed in layers and a long plaster spica is applied in the extended and abducted attitude. This remains for several weeks in order to assure the fixation of the trochanter in its new position. The after-treatment will vary according to the circumstances of the patient. If early locomotion is desired, as in the cases in which the hospital expense is a burden, a short spica extending only to the knee holding the limb in about 20° of abduction is applied and the patient is discharged on crutches, weight bearing being permitted if it causes but little discomfort. In cases which remain under supervision the limb is usually suspended from a frame by pulleys, and passive and later voluntary movements are begun, regulated by the degree of discomfort. The most important factor in the after-treatment being persistent, methodical stretching of the limb outward to the proper degree of abduction and backward to complete extension, thus checking the tendency toward the former attitude of flexion and adduction and resulting compensatory shortening of the limb.

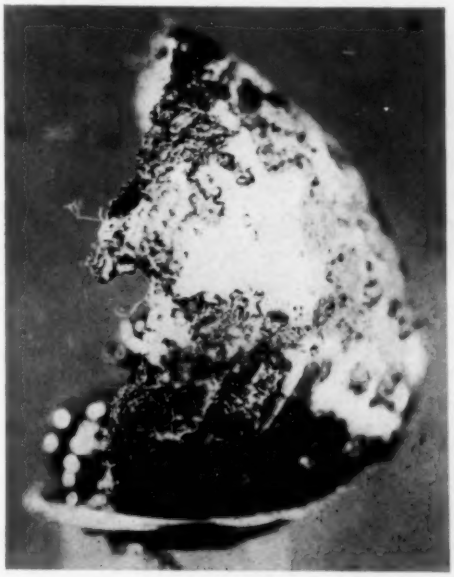

FIG. 9.—Case II. Showing the bone removed and the condition of the cartilage.

As all the operations have been performed practically within a year and several very recently, one can not report on final results. The first operation was performed in November, 1922. This was a typical case of morbus coxæ senilis. The patient, a chauffeur, sixty years of age, was completely disabled because he could not get in or out of his car. When last seen he stated he could walk five miles and that he could sit with comfort. The immediate effects in all the cases have been satisfactory. The deformity of the adducted limb and tilted pelvis has been corrected, the range of motion increased, and the pain on movement and weight bearing has been reduced to discomfort. It would appear furthermore, that the patients may be assured of progressive improvement as contrasted with progressive disability and that the results already attained have substantiated the theory on which the treatment has been based.

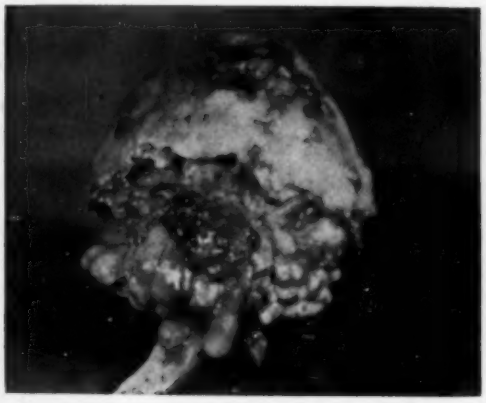

FIG. 10.—Specimen removed from Case VII.

TRANSACTIONS

OF THE

NEW YORK SURGICAL SOCIETY

Stated Meeting Held May 14, 1924

The President, Dr. Eugene H. Pool, in the Chair

RADIOTHERAPY IN HODGKIN'S DISEASE

Dr. Morris K. Smith presented a boy who had applied for treatment at St. Luke's Hospital Dispensary, September 3, 1919, with a history of swelling of the left side of the neck of three weeks' duration. At this time he was ten years of age. Back of the angle of the jaw on the left side was a mass made up of rather soft discrete glands measuring about 8 x 6 x 4 cm. There was spasm of the sterno-mastoid on that side. In the lower jaw there was a molar tooth with a large cavity. The tonsil on the same side was described as ragged in spite of his having had a tonsillectomy several years before. No further abnormalities noted.

For the next two and one-half months he was treated with local applications. The bad tooth was extracted. The condition improved but the glands did not clear up. A gland was then removed for diagnosis and was reported as typical Hodgkin's disease. An X-ray of the chest at this time was negative for mediastinal enlargement. He was referred for radiotherapy. Two fractional treatments cleared up the nodes in a month's time.

A year later he returned with numerous small nodes which had been present two weeks. Two courses of radiotherapy were given in the succeeding year.

He was next seen in January, 1924, more than four years after original treatment. Mother at this examination thought he tired easily, but he was in high school and took part in games with other boys. He looked a little pale. The whole posterior triangle of the left side of neck was filled with glands, making a mass about 10 cm. in diameter. Just back of the angle of the jaw was a mass of glands under sterno-mastoid about 5 x 7 cm. Right side of neck, axillæ and groins contain a few tiny nodes not more than are often palpable in health. Spleen not palpable. No mediastinal dulness, no cough. Patient and his mother stated glands varied in size and were more likely to swell in winter. At this time he was referred back to the radiotherapy department, where under treatment the nodes again cleared up.

The notable features of this case are recurrent glandular swelling of the left side of the neck, diagnosed on biopsy as Hodgkin's disease; the apparent restriction of the disease to this area; the prompt response to radiotherapy, and the excellent general health without, at this time, four and one-half years after onset, evidence of the disease. According to the authority of the examining pathologist, the sections obtained from the glands removed from this boy were positively typical of Hodgkin's disease.

Dr. William B. Coley said that these cases are difficult to differentiate from lymphosarcoma, particularly with the absence of liver- and spleen-involvement. This was illustrated by a case which he had had at the

Memorial Hospital ten years ago, with a history of tumors of the neck, and which was regarded as a lymphosarcoma. One of these tumors was removed and pronounced by the pathologist of Bellevue Hospital as a lymphosarcoma. About a year and a half later the tumors recurred locally and the patient was referred to the Memorial Hospital as an inoperable case. She then had a mass of glands in the right cervical region, one of which was removed for diagnosis. The condition was pronounced Hodgkin's disease by Doctor Ewing. The patient was treated by prolonged toxin injections combined with the X-ray. During her six months' stay at the Memorial Hospital she showed marked improvement; but later on developed a condition of the lungs which was believed to be metastases, and the case was regarded as hopeless. She was then lost sight of, until eight years later, when Doctor Coley was called in to see her for an acute abdominal condition, which caused her death a few days later. A careful examination at this time by Dr. William A. Downes and himself, failed to show any evidence of the old Hodgkin's trouble.

RENAL TUBERCULOSIS

Dr. Charles E. Farr presented a woman, thirty years of age, who entered the New York Hospital, June 7, 1919, and was discharged June 21, 1919. She then had a typical attack of acute appendicitis with high temperature, rapid pulse, a rigid and very tender abdomen. There was a history of right-sided pain since childhood with recurrent attacks of indigestion about every three weeks. Operation was performed at once. The appendix was acutely inflamed and apparently about to perforate. It was removed. Exploration showed an extensive tuberculous involvement of the tubes, ovaries and pelvic peritoneum. A bilateral salpingectomy was done and the wound closed. Recovery was uneventful except for a slight breaking down of the wound. This drained a few drops of serum for a long time. Microscopical examination of the tubes showed extensive old lesions of tuberculosis within the lumen but none on the outer surface of the sections examined. The outside was covered with fibrino-purulent exudate.

During this stay in the hospital the urine showed a marked trace of albumen and a few white blood corpuscles. There was considerable acetone and diacetic acid. There were no urinary symptoms and the frequency of urination was normal, three to five times a day. Recovery was uneventful, the general health improved and she returned to work, against advice. Pain in the right side continued. The menses were normal, regular and painless.

In February, 1920, micturition became frequent and painful with some blood for a period of two months at the onset. Frequency ran up to fifty times per day and the pain was excruciating. Pain in the lower left abdomen began and grew steadily worse. It was paroxysmal at first but soon became steady and very severe. There was slight fever, no night sweats, about ten pounds loss in weight and much loss of strength. The appetite remained good.

Examination showed a pale, anæmic girl with a suspicious spot at the right apex but no active lesion, tenderness over both kidneys, especially the left, and some rigidity of the abdomen. The lower lumbar spine presented a tender prominence and X-ray showed a definite destructive and productive lesion of the fourth and fifth lumbar vertebræ.

Cystoscopic examination, July 29, 1920. Urethra inflamed. Instrumentation very painful. Bladder capacity 60 c.c. No residual. The mucosa of the fundus, and especially just back of the trigone, was severely inflamed. Few trabulations were noted. Mucus was marked. The right ureteral orifice was inflamed but normal in size and position, the left was even more inflamed. The vesical orifice was inflamed, œdematous and showed an irregular outline. Catheter passed on the right without obstruction and with slight trauma. Three minutes flow gave 15 c.c. of slightly bloody urine. Phenolsulphonephthalein appeared in six and one-half minutes and gave 8 per cent. in fifteen minutes. Microscopical examination showed pus and a few red blood cells. Tubercle bacilli were not found. Urea .2 per 100 c.c.

The left ureter was easily catheterized and yielded 5 c.c. in three minutes. The urine was hazy. There was no trauma. The dye appeared in three and one-half minutes and was 9 per cent. in fifteen. The urine contained pus, no red blood cells, gave urea .1, and showed the presence of tubercle bacilli. The total dye excreted in the first hour was 34 per cent., in the second 11 per cent., a total of 45 per cent. Advice was given against operation by the consultant because of the probable bilateral involvement. Bladder irrigations and instillations were tried without avail, as were various drugs. On August 24, another cystoscopy was done, showing an advancing process with ulcerations of the trigone and the left ureteral mouth. The right side showed no definite tubercular ulcerations. Left nephrectomy was advised even in the presence of presumed bilateral trouble, as the condition was getting desperate and the left kidney was definitely the worse. On August 27 the kidney and upper ureter were removed without difficulty. The upper pole showed a patch 3 cm. in diameter, mottled yellow with white spots, resembling tubercles. Microscopic examination showed tuberculosis of the kidney and ureter and also a minute papillary adenoma, benign in character.

There was a rather sharp reaction to the operation, but improvement slowly followed. The bladder symptoms were most distressing. The wound healed per primam but broke down later with slight serous discharge for many months. Spontaneous healing eventually occurred. The patient's general condition was miserable for about a year but slowly improved. The bladder is not yet clear but has markedly improved. The urine still contains considerable pus and mucus. Urination now is nearly normal in frequency at night and during most of the day. The patient now weighs more than ever, about 130 pounds, a gain from about 80 pounds at the worst. She works every day and aside from the long-persisting pain in the right side and occasional frequency of micturition, considers herself well.

This case was considered to be bilateral by all the consultants, but absolute proof is lacking. Even if it was not, recovery from such extensive and generalized tuberculous lesions is noteworthy. It reflects credit especially on the courage and "will to live" of the patient.

Dr. Robert T. Morris said, regarding the infection of kidneys, ureters and bladder in a case in which the tubercle bacillus was not actually found, the speaker felt that perhaps a virulent colony of the colon bacillus might have been responsible. Sometimes this bacillus will act as a terminal infection after actual recovery from tuberculosis. Frequently colon bacillus invasion of the urinary tract is mistaken for tuberculosis and in that case is amenable

to treatment with vaccines, urotropin and attention to the focus of colon bacillus invasion.

PERITHELIOMA OF THE CAROTID GLAND

Dr. Charles E. Farr presented a woman, twenty-seven years of age, who entered the New York Hospital, June 13, 1923, and was discharged June 21, 1923. Her chief complaint was of loss of strength and of a swelling in the right side of the neck. This had been noticed three or four years, had grown slowly, was tender, sensitive to cold, but had caused no real anxiety. She felt weak, tired and run down.

The past history was negative. Her health had been good up to five years ago when she had her tonsils removed and her teeth cared for. She has had occasional gastric upsets. Her mother died of a carcinoma of the breast.

Physical examination revealed nothing abnormal save the swelling in the right side of the neck. This was 4 x 2 cm., rather lower than the top nodes of the deep chain, hard, slightly tender, attached deeply but not to the skin. It was considered a tuberculous node and operative removal was advised. Her general condition was fairly good, the lungs were clear both by clinical observation and the fluoroscope.

Fig. 1.—Perithelioma of carotid gland.

Operation was performed under nitrous oxid-ether anæsthesia, the growth being exposed by a transverse incision. It was found lying in the bifurcation of the common carotid and was at once recognized as a tumor of the carotid body. The mass was encapsulated but was strongly adherent to the sheaths of the internal and external carotids. Sharp dissection was necessary and considerable of the adventitia of the vessels was removed with the tumor. The grooves made by the vessels in the growth were well marked after removal.

Recovery from the operation was uneventful and the result has been excellent. The patient has recovered her strength and weight and feels as well as she ever did. She had a number of X-ray treatments by Doctor Remer, spent the summer at the shore and has been able to keep up her full duty as a nurse ever since.

The pathological report is as follows: The tumor mass is 3½ x 2 x 2½ cm. It is smooth, covered with a thin capsule and the cut surface shows a firm gray tissue with slightly softened centre. Frozen section shows the lesions of a perithelioma of the carotid gland. Examination by Doctor Stillman. Paraffin sections confirms the diagnosis of perithelioma. (Fig. 1.) "This name is objected to on the ground that the cells are not comparable to the so-called perithelial cells found in other structures. However, until the nature of the

gland is established, no definite opinion concerning the nature of the cells composing the tumor from the specific cells can be advanced. We therefore adhere to the original nomenclature." Report by Doctor Elser.

DR. JOHN DOUGLAS said that though few surgeons had sufficient experience with these cases to speak with authority, he had had one case, which he reported ten years ago, in which, contrary to the statement that the rule in these cases is that they usually recur locally and sometimes but rarely metastasize, the patient was alive seven or eight years later with no sign of recurrence.

SARCOMA OF LEG

DR. CHARLES E. FARR presented a man, thirty-one years of age, a mechanic, who entered the New York Hospital, Cornell Division, service of Doctor Gibson, December 30, 1920, and was discharged January 24, 1921. His chief complaint was of a bleeding mass in the right leg just above the ankle.

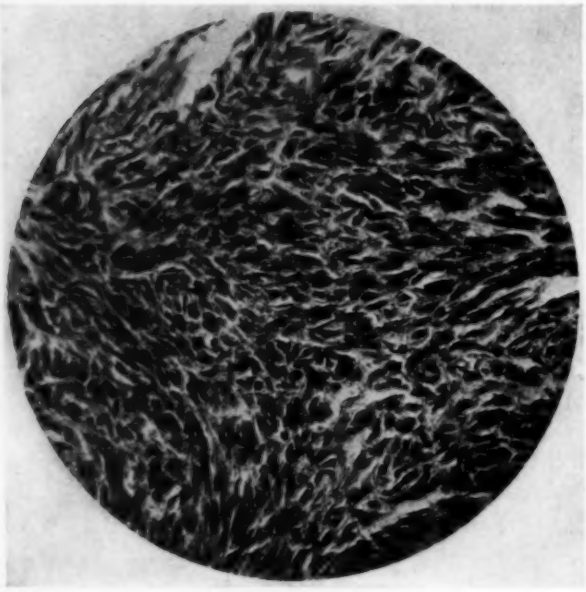

FIG. 2.—Sarcoma of leg.

The present trouble began in 1911 when he sustained a compound fracture of the right tibia and fibula near the ankle. Before the wound healed a swelling was noted in the surrounding tissues and has continued to increase slowly ever since. The wound eventually healed but in 1915 it was crushed open between two barrels. He spent a month in hospital and again the wound healed. In 1918, he entered another hospital and the growth was excised. The wound healed but the growth promptly recurred in the margins. The growth was pronounced a myosarcoma.

One month before admission the mass again broke through the skin and this time began to bleed. Pain was intermittent, jumping and radiating to the great toe. The past history is negative except for a chancre at nineteen years of age, which was treated. There were no secondary manifestations. The family history is negative. Physical examination revealed a large, soft, fungous mass just above the right ankle extending well to the sides under the skin. There was an old operative scar and a bleeding mass of smooth red granulating tissue 5 cm. in diameter protruding from it. (Fig. 3.) The lateral masses are semifluctuant. There are a few enlarged nodes in each groin and in the axillæ. The patient was in excellent general condition with normal blood count and negative blood Wassermann on two occasions. He was put on a vigorous mixed treatment without benefit.

X-ray examination showed an old healed fracture of the tibia and fibula with a tumor in the soft parts, suggestive of periosteal sarcoma.

A biopsy was done January 1, 1921. "The growth is composed of closely packed spindle cells of medium size, showing a moderate number of mitotic figures. It is transversed by many irregular channels lined with endothelium, some of which contain blood. Diagnosis, spindle-cell sarcoma." (Fig. 2.)

On January 8, 1921, the leg was amputated above the knee. The specimen was described as follows: "There is a new growth on the ankle with skin absent in part. It is 5 cm. in diameter, raised 2 to 3 cm., and there are lateral masses the size of hen's eggs, with intact skin. On dissection the growths are located in the subcutaneous tissue. The growths on the side of the ankle are sharply demarcated and only loosely connected with the periosteum of the tibia. About 5 cm. above the growth is a thickening of the

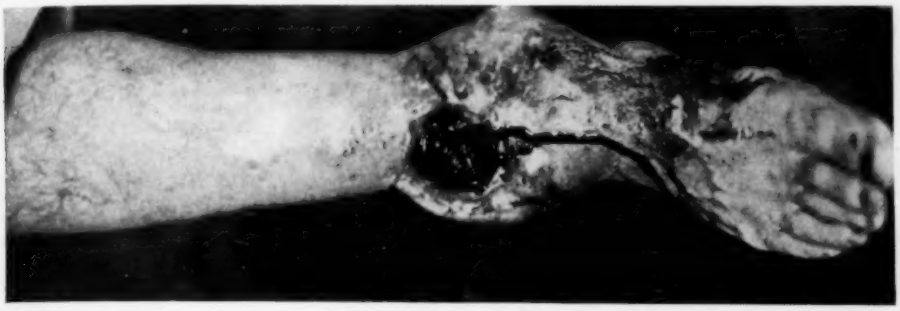

FIG. 3.—Sarcoma of leg.

cortex, resembling an old callus. Microscopical sections of the tumor present the features of a spindle-cell sarcoma. The cells are of medium size. Blood sinuses are numerous."

The stump healed kindly, the post-operative reaction was mild. Two X-ray treatments were given before operation without apparent benefit. Three series of post-operative treatments were given in the succeeding three months, all in the inguinal region. What seemed a definite recurrence in the stump was noted during this time along with masses of enlarged nodes in the groins. No sections were made. Repeated examinations with radiograms at regular intervals since have failed to reveal any signs of recurrence or of metastasis. His general health is excellent.

The chief interest in this case, aside from its prolonged course and apparent cure, is in the speculation as to the source of the growth. It was generally considered in the hospital to be a periosteal spindle-cell tumor arising from the tibia, but a critical examination of the available data leaves an element of doubt.

DR. DOUGLAS SYMMERS (by invitation) said that he was impressed by Doctor Farr's statement concerning the duration of the patient's illness, the situation of the growths and their color, and he wondered if it might not represent a variety of sarcoma which had originated as a granuloma. He referred more particularly to the so-called multiple idiopathic hemorrhagic sarcomata of Kaposi, the clinical features of which reminded him of Doctor Farr's patient. He had had the opportunity to study several cases of this variety of disease, and recognized two histological types—one a chronic productive inflammatory or granulomatous lesion, the other a spindle-cell sarcoma.

SARCOMA OF UTERUS

DR. CHARLES E. FARR presented a woman, twenty-eight years of age, who entered the New York Hospital, July 26, 1920, and was discharged September 15, 1920, on the Cornell Division, service of Doctor Gibson. Her chief complaint was pain in the lower abdomen. This had lasted about a year, was worse on the right side, and recurred monthly with vomiting, constipation and fever. She had had a severe attack two days before admission.

There had been a previous admission to the service in 1917 with a similar history. Following a miscarriage there was a moderate leucorrhœa. For this a curettement was done and lacerations of the pelvic floor repaired. Under the anæsthetic the uterus was noted as slightly enlarged, the fornices were negative. Recovery was uneventful and the patient remained in good health until the second admission. She had had previously two healthy children. Her family and past history were negative.

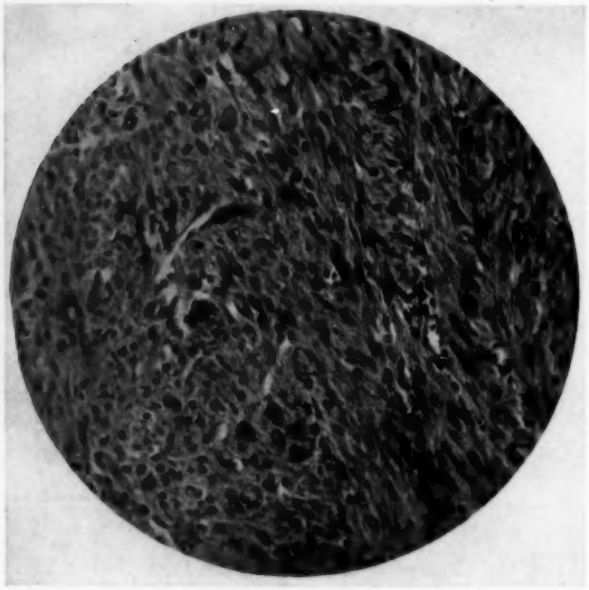

FIG. 4.—Sarcoma of uterus.

Physical examination on the second admission failed to reveal anything noteworthy except moderate tenderness in the lower abdomen and also rather marked tenderness in the fornices.

Laparotomy was done July 26, 1920. There were a number of small subperitoneal and mural fibroids, the largest 2 cm. in diameter. This latter was mural and was removed with more than the usual difficulty in doing a simple myomectomy. The tubes and ovaries were normal, the appendix mildly inflamed. It was removed. The gall-bladder was also inflamed and full of calculi and it was removed. Recovery from the operation was uneventful.

The pathological report on the larger tumor mass was as follows: "A small fibroid tumor, 2 x 1 x 1 cm. and another the size of a French pea. Microscopical examination of a frozen section shows a very cellular myoma of the uterus with evidences of a turbulent proliferation of the cells. Giant cells with single and multiple giant nuclei indicate sarcomatous transformation. Whether the growth shows invasive properties cannot be decided from the section. Grossly the tumors appear well circumscribed. The appendix is involutional. The gall-bladder shows chronic inflammation and contains 30 yellowish-white facetted stones. There is marked atrophy of the mucosa and muscularis."

After consultation with Doctor Elser it was deemed wiser to remove the uterus and this was done, August 19, 1920, the tubes and ovaries along with the uterus to the cervical stump being ablated. Nothing abnormal was noted either grossly or microscopically save a tiny fibromyoma near the cervix.

A broad band of hyalinized connective tissue near the surface was considered a part of the original tumor capsule. In it are several small foci of foreign body giant cells, but no evidence of new growth. The ovaries showed a number of small cysts containing clear fluid and a few with bloody gelatinous material.

Again recovery was uneventful. A series of X-ray treatments were given and the patient has been well ever since, except for mild menopause symptoms. In January, 1921, there were mild gastric symptoms and a small filling defect on the lesser curvature pre-pyloric, but she improved under simple remedies. In June, 1921, she was again operated upon for a femoral hernia. The inguinal ring was also opened and an exploration of the pelvis revealed nothing abnormal.

Repeated microscopical examinations of paraffin sections confirm the diagnosis of leio-myosarcoma. (Fig. 4.)

CURE OF FLAIL SHOULDER BY ANKYLOSING THE SHOULDER JOINT

Dr. H. H. M. Lyle presented an ex-soldier who was wounded at Ypres in September, 1918. He sustained a shell wound of the right shoulder with paralysis of the circumflex nerve. After a series of operations extending over more than five years, the arm hangs by his side and he cannot abduct it more than 10°. He entered St. Luke's Hospital, December 15, 1923, and was operated on four days later; an ankylosis of the shoulder joint being performed and the arm fixed in plaster. The arm was abducted to about 60° with the elbow joint in front of the corneal plane, so that the middle finger of the hand would reach the centre of the opposite clavicle; the cast was removed at the end of eighty days.

The X-ray of the shoulder before operation shows the acromion, coracoid and the outer portion of the spine of the scapula missing—a free fragment of bone represents what is left of the acromion—this was used as a wedge in the ankylosing operation. The functional result is excellent. He can comb his back hair, fix his collar button and reach into his hip pocket.

The main object in presenting this case is to show how useful a good ankylosis of the shoulder is. Here is a man who has undergone a nerve operation, a transplantation of a portion of his trapezius, two bone grafts, an arthrodesis and two other unknown procedures. It is perfectly obvious that from the first an ankylosis of the shoulder should have been performed, this would have saved these useless operations. It is a well-known fact that arthrodesis of the shoulder often fails. A bony fixation in good position gives excellent functional results within a few months. An arthrodesis should not be attempted in the face of an extensive bony destruction or where the deltoid or the muscles attached to the tuberosities are damaged or paralyzed, or where strength rather than mobility is desired.

He was led to emphasize these points by the fact that it had been his misfortune to examine a number of veterans who at the end of five years have useless arms, victims of ill-advised bone grafting, arthrodesis and muscle transplantation.

Dr. Royal Whitman said that his experience had been practically confined to paralysis in childhood. In the class in which it was difficult to assure firm ankylosis, the arm was usually brought to a right angle with the scapula in order that the acromion might be embedded in the head for greater security.

INJURY TO SHOULDER JOINT

DR. H. H. M. LYLE presented also a case of shell wound of the shoulder with partial destruction and dislocation of the head of the humerus, with the formation of a new joint between the head of the humerus and lower edge of the glenoid, complicated by fibrous ankylosis of all the finger joints, due to prolonged immobilization.

This man entered St. Luke's Hospital, July 10, 1923, with a history that while serving with the 27th Division in September, 1918, he was wounded in the right shoulder. He has had twelve operations in all. The X-ray shows that the deformed and dislocated head has formed a new joint on the lower border of the glenoid. Compare for a moment the functional ability of this patient's arm with that of the one with the ankylosis. The maximum abduction is 20 per cent. and he cannot abduct against resistance; in other words, the only value of this arm lies in the forearm and hand. Fortunately this man is a clerk and does not need much power.

When he came to the hospital all the finger joints were ankylosed in a position of extension, and it was impossible for him to grasp. The right hand presents fibrous ankylosis of all the metacarpal and phalangeal joints with the exception of the thumb; the extensor tendon had undergone adaptive shortening. He had had a thorough course of physiotherapy without improvement. At the end of ten months' further treatment he now has a perfect grasp and motion in all joints with the exception of the terminal joint of the little finger. He was treated by the method of gradual flexion and wedging as previously demonstrated before this Society.

OSTEO-CHONDRITIS OF PATELLA

DR. ALEXIS MOSCHCOWITZ presented a woman, who was admitted to Mt. Sinai Hospital, November 19, 1923, complaining of swelling and disability of the left knee-joint which had lasted four weeks. She stated that approximately six years ago she felt the left knee-joint give way; following this she experienced pain for several weeks with some enlargement of the joint. Her present illness dates back about two weeks and began suddenly while dancing, when she felt again the left knee give way and she was unable to support herself upon it; there never was a definite locking of the joint. Since that time the knee-joint has been stiff and swollen with inability to flex the joint beyond 120 degrees. Physical examination showed that the circumference of the left knee-joint was about 1½ inches larger than the right. X-ray examination did not show anything very definite to account for the condition. Under conservative treatment there was absolutely no improvement in the condition. Under these circumstances it was decided to operate on the patient, with a provisional diagnosis of dislocation of the internal semilunar cartilage.

Operation, November 27—gas and ether anæsthesia. An incision 4½ inches in length was made parallel to the inner border of the patella. Inspection revealed the semilunar cartilage to be intact and in place.

The patella was now rotated in order to expose the cartilaginous surface. When this was done there was to be seen projecting from its under surface a small cartilaginous mass of tissue, free at its upper end but still attached at its lower margin, where it merged with the underlying bone. It was about the size of the end of a nail and formed an angle of 30 inches with the cartilaginous surface of the patella. This projecting piece of cartilage was excised. The joint was closed in layers. Primary union resulted. Gentle active and passive motions were instituted about eight days after operation.

She was discharged from the hospital, December 23, 1923, at which time the patient could flex her leg voluntarily beyond a right angle, without pain. Since her discharge the improvement has continued and she is now absolutely normal in every respect. On reëxamining the plates after operation there was to be seen a slight projection on the posterior surface of the patella and there is no doubt that it corresponds to the pathological findings found at the operation.

BILIARY FISTULA OF VERY LONG DURATION

Dr. Alexis V. Moschcowitz presented a woman, forty-six years of age, who was referred to him in December, 1921, with typical attacks of cholelithiasis, for the relief of which he performed cholecystectomy, December 22, 1921. It is important to note that contrary to Doctor Moschcowitz' custom he extirpated the gall-bladder in this case from above downward. The operation was unusually easy, the entire period consumed being just 35 minutes. The specimen consisted of the gall-bladder cut across at the cystic duct and contained two very large calculi and a number of small ones. On the tenth day after operation the patient developed a biliary fistula, and at no time after the formation of the biliary fistula was there any bile present in the fæces. At about this time also during one of the dressings, as the wound was being irrigated, a slough about 1½ inches in length was discharged from the wound. This tissue may have been the duct, but it was too degenerated to be recognizable.

For the next month all the bile continued to discharge through the fistula. As no progress was made, a second operation was done for the closure of the biliary fistula February 2, 1922. Owing to unusually dense adhesions, the exposure was very difficult. After considerable search the hepatic duct was recognized practically at the portal fissure. Only a minimal piece was left for the subsequent manipulations. No amount of search, even after complete mobilization of the duodenum, revealed any trace of the common duct. The search for this structure was abandoned after three hours. The operation was therefore finished in the following manner. A rubber tube was threaded into the stump of the hepatic duct. A small opening was made into the duodenum and the tube introduced. The duodenum was next sutured to the stump of the hepatic duct and the entire suture line surrounded by omentum. The wound was closed, but drained by a massive rubber dam packing.

No bile leaked for the first week. Then again a biliary fistula formed which in the course of a few days again became complete. Patient was discharged with a complete biliary fistula two and one-half months afterwards.

She was seen again in June, 1923, at which time the fistula was complete and not even a trace of bile was present in the stool. Barring the presence of the biliary fistula, which quite naturally required frequent dressings, the patient was perfectly well and had gained a great deal in weight and strength.

About a week after her last visit she noticed for the first time in two years some color in the fæces. About one week after that the wound closed and has remained healed since that time.

An X-ray taken recently showed no trace of the tube which was implanted at the hepatico-duodenostomy.

There are several notable points about this case: (1) The formation of a complete biliary fistula after a simple cholecystectomy, without any injury whatsoever to the common duct. (2) Perfect health and digestion in the presence of a complete biliary fistula. (3) The long duration of the fistula. (4) Spontaneous closure of the fistula.

Dr. Allen O. Whipple reported some cases of biliary fistula that, although they did not close spontaneously, he considered interesting in comparison with the one Doctor Moschcowitz presented. The operations were also entirely uncomplicated and very simple, and in one the gall-bladder had been removed from the fundus down to the cystic duct, and in the other the cystic duct had been carefully severed and ligated. In both cases a biliary fistula developed and existed, one for three months and in the other for seven weeks, and a second operation was done. Careful dissection was done in attempting to find the common duct and the gastrohepatic omentum was dissected without finding any evidence of any duct. In one of these cases it was thought that occasionally bile was present in the stools. This fistula was opened and a probe was passed which did not seem to go into the duodenum. In one case death resulted in two years from cholemia and the other patient was lost sight of. Both were uncomplicated cholecystectomies. In the dissections no remains of the common duct could be found. Both were drained cases and in one a rubber tube was used, which it was thought might have impinged on the gastrohepatic omentum, causing connective-tissue displacement of the common duct.

Dr. John Douglas said that although he had no explanation for Doctor Moschcowitz' case, he did think it well to emphasize the fact that these fistulæ can happen without any division of the common duct at the time of operation. This should be emphasized so that when a surgeon is sued for the development of a biliary fistula he can point to the records showing that men of such ability as Doctor Moschcowitz and Doctor Whipple have had similar experience. In a case of his own a very severe infection followed a cholecystectomy and resulted in actual destruction of part of the duct which had been drained. There was increasing jaundice and the patient developed stenosis of the common duct. Secondary operation showed destruction of about 1 cm. of the common duct, which was dissected out and brought end-to-end. The patient was shown before the Surgical Society as cured, but came back again deeply jaundiced and with no bile in the stools, which later cleared up, but every two or three months she now has attacks of jaundice. This was from a secondary infection and not from injury at the time of operation, and the speaker believed that the fact that this occurred should be put on record.

DERMOID CYST OF TONGUE

Dr. Alexis V. Moschcowitz presented a woman, twenty-one years of age, who was admitted to his service at Mt. Sinai Hospital, December 4, 1923. Her history dates back to the very earliest childhood, when she first noticed that her tongue became swollen so that she could not talk or swallow. At the age of eight the swelling ruptured spontaneously and discharged pus through the mouth. Since that time the patient had been operated upon six times at varying intervals, most of the incisions being external incisions parallel with the lower jaw. After the last operation a drainage tube was kept in for six months and the patient was advised to inject boric acid solution through the tube. On one such occasion she noticed that the injected fluid

escaped through the mouth and she could repeat this performance at will. Upon removal of the tube, however, the wound healed up promptly. Since that time there occurred very frequently a reopening of the neck wound with a discharge of pus for a few days.

When she entered the hospital the physical examination presented the following local condition. There was a broad transverse scar, the seat of a keloid, situated more on the left side than on the right. There was no fluctuation and no discharge from the scar. The tongue protrudes normally in the midline. On its upper surface midway between the tip and line of the circumvallate papillæ, directly in the midline, there is a small excrescence into which a very fine probe can be made to enter for a distance of about one centimetre. There was no discharge from this sinus. An attempt was made to inject the sinus with bismuth and to X-ray the same. This attempt was however unsuccessful. In view of the long history of the case, a preoperative diagnosis of dermoid cyst of the tongue was made.

December 10, operation in gas and ether anæsthesia. An incision four inches in length was made on the under surface of the chin, excising all the old scar. A probe was inserted into the sinus on the dorsum of the tongue. The mylohyoid muscle as well as the underlying hyoglossus, geniohyoglossus and genioglossus were divided transversely. With considerable difficulty the probe introduced from the dorsum of the tongue was located in the midline. The right lingual artery was ligated. The entire tract extending from the floor of the mouth to the opening on the dorsum of the tongue was excised *en masse*, finally excising a small piece of the mucous membrane of the tongue. This was sutured with plain catgut and all of the muscles sutured together as well as possible with interrupted sutures, drainage by means of small piece of rubber dam. Uneventful recovery followed and patient was discharged healed December 28, 1923.

The excised specimen contained in the mid-portion a small cyst filled with sebaceous material and hair. Pathological report by Doctor Mandlebaum confirmed the diagnosed of dermoid cyst.

Cases of dermoid cyst of the tongue are exceedingly rare, so rare indeed that very few cases have been reported in medical literature. He had requested his adjunct surgeon, Doctor Colp, to publish this case in conjunction with other published cases.

LYMPHOID HYPERPLASIA OF THE APPENDIX IN CHILDREN. ITS RELATION TO RECURRENT APPENDICITIS

Dr. Thomas A. Smith read a paper with the above title, for which see Annals of Surgery, 1924, vol. lxxix, p. 871.

Dr. Douglas Symmers (by invitation) said that he had seen lymphoid hyperplasia of the appendix in three grades. The first is characterized by simple hyperplasia of the follicles, and removal of the appendix is followed by disappearance of symptoms. If the appendix in these circumstances is left in the body, the lymphoid hyperplasia subsides and then recurs, and, after a number of such attacks, becomes associated with sclerosis of the connective tissues as a result of mechanical reaction to increase in the size of the follicles. Finally, the connective tissue of the appendix completely replaces the structures of the mucous membrane and the lumen becomes obliterated. This latter change is found most frequently in older children or young adults, and represents a replacement fibrosis and not an inflammatory lesion. His experience with

these three types of lymphoid hyperplasia of the appendix, both clinically and at autopsy, led him to believe that the condition was a part of status lymphaticus, which condition, however, does not necessarily constitute a contra-indication to operation, in spite of the fact that there is a widespread impression that subjects of status lymphaticus frequently die suddenly under apparently trivial provocation. As a matter of fact, about one out of every ten persons is a subject of status lymphaticus and sudden death among them is a rarity. When it does occur, however, the circumstances are so dramatic as to create a profound impression and to exaggerate the dangers that attend this type of individual.

Dr. Robert T. Morris said that when Doctor Symmers' paper on "Lymphoid Hyperplasia of the Appendix" was published, he looked into the matter and found that some of the cases which he had previously described as fatty degeneration of the appendix and as fibroid involution doubtless belonged in the lymphoid hyperplasia group. Degenerative lesions in the germinal areas would lead to fatty changes and connective-tissue hyperplasia might follow. The speaker believed that pain referable to the appendix in lymphoid hyperplasia was due to the swelling of soft tissues of the appendix within the constricted container of peritoneum.

Chronic appendicitis may be classified pretty well under four categories. There is one infective lesion and three irritative lesions. Low-grade infection with little tendency to acute phases was not the most common form of chronic appendicitis. The most frequent chronic form was the irritative involution lesion, not infective, with or without lymphoid hyperplasia. Appendix symptoms here were due to inclusion of nerve filaments remaining in contracting connective tissue.

Another irritative lesion, congestive in its nature related to disturbances of circulation in connection with cases of relaxed peritoneal supports. A third irritative lesion included lymphoid hyperplasia. All four kinds of chronic appendicitis give symptoms that are much alike. There is tenderness on deep pressure a couple of inches to the right of the navel and a little below, corresponding to the site of the fused ganglion of the lumbar sympathetic system. Tenderness on deep pressure over the appendix itself at McBurney's point, on the other hand, related to acute infective lesions of the appendix.

Briefly in all forms of chronic appendicitis the fused ganglion is hypersensitive on pressure, but in all forms of acute appendicitis the appendix itself is hypersensitive on deep pressure.

PREVENTION OF POST-OPERATIVE BLEEDING AFTER BLOODLESS OPERATIONS

Dr. Theodore Dunham said that when using the procedure he was about to describe, he did not, at the conclusion of the operation, remove the constricting rubber bandage. Small vessels and bleeding points he did not seek out, ligating or twisting off only evident vessels. This saves time and reduces or eliminates the placing of ligature material in the wound. Any required

drains are now placed and the wound is sutured; the appropriate dressing is applied and secured with bandages or otherwise. All the foregoing is done while the operation region is still bloodless. At this point apply an exceedingly snug bandage of gauze or muslin over the completed dressing. Only after this very snug enveloping bandage has been applied is the rubber constricting bandage removed. In spite of the tight enveloping bandage, some blood will percolate through the tissues and the toes or fingers will regain color. The tight bandage is left in place for two or three hours and then removed. The removal of this bandage does not disturb the dressing or the wound beneath it. They are simply relieved of the unusual pressure.

At the dressing of wounds so managed, he finds little oozing into the dressings and the wounds dry. The merits of this procedure are saving of time in operation and the saving of blood. He had used it in appropriate cases for over thirty years, in operations varying in magnitude up to resection of the knee and had thus far met no drawback. He did not advocate this method as a cloak for carelessness in hæmostasis, but to save the loss of blood and loss of time ordinarily consumed in caring for tiny vessels and the parenchymatous oozing which follows the removal of a constricting rubber bandage.

CORRESPONDENCE

NATURE'S CURE OF CHOLECYSTITIS

EDITOR ANNALS OF SURGERY:

Sir:

Since I have adopted the practice, when opening the abdomen for any specific lesion, to make a parietal incision large enough to permit the exploration of the whole peritoneal cavity, I have been amply rewarded by the number of unexpected things found. Occasionally I have met with what seemed at first to be the absence of a gall-bladder, but on further examination have always found a small contracted mass deeply attached and densely adherent to the under surface of the liver in the region of the foramen of Winslow, which proved to be a greatly contracted gall-bladder the coats of which had undergone such fibrotic thickening that showed that there had been at some time an acute or continued infection which had resulted practically in the destruction of the organ. About once in every fifty cases of operation for gall-stones in which a history of many previous attacks may be elicited, I have found a similar condition with one or more gall-stones out of sight and often out of reach, embedded in a shrivelled up, deeply placed and deeply adherent sac. In some of these cases, calculi have been found co-existing in the hepatic ducts. It is often the case that these conditions are found in patients who are bad subjects for any operation, much more so for one in the depth of the upper abdomen. The conditions are such as to warn the prudent surgeon to abandon all thought of cholecystectomy and to content himself with simply opening the contracted fibrotic sac and removing any calculi present, after which, aided by traction upon the thick fibrous-walled bladder, making a further search for calculi in the ducts. If any are found in the hepatic ducts or high up in the common duct, they may be milked down by the surgeon's fingers into the terminal common duct where the duct may be incised and the calculi shelled out. The wound in the common duct need not be sutured—a wisp of silkworm gut, doubled and tied near the ends, is placed near the opening for drainage, but may be dispensed with within a week as a rule owing to the rapid healing of the wound. The cavity of the contracted gall-bladder is also purposely left wide open with a similar wisp of silkworm gut left in place for drainage.

My advocacy of this manner of treating an exceptional condition of the gall-bladder, will not be interpreted as in any way inconsistent with my advocacy for years of cholecystectomy as the best treatment in general for cholecystitis.

JOHN O'CONOR, M.D.,
Buenos Aires, Argentina.

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